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EXPOSURES TO MULTIPLE ENVIRONMENTAL CHEMICALS (LEAD, METHYLMERCURY AND POLYCHLORINATED BIPHENYLS) AMONG CHILDBEARING-AGED WOMEN IN THE U.S.

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ABSTRACT

It is estimated that 5 to 20% of neurodevelopmental disabilities in children are caused by environmental toxic exposures. Lead, methylmercury and polychlorinated biphenyls (PCBs) are known to have neurobehavioral and neurodevelopmental consequences in animal models and human population studies. Bioaccumulation and exposures during gestation transfer from mother to fetus via the placenta and to an infant and young child through lactation. Little is known about multiple environmental chemical exposures, especially among childbearing-aged women.

This descriptive and exploratory study involved analysis of existing data from the National Health and Nutrition Examination Survey (NHANES), a national probability sample. Lead, methylmercury and the summed value of four lipid-adjusted PCB congeners (118, 138/158, 153, 180) were measured in the blood or serum of childbearing-aged females aged 16 to 49 of diverse races and ethnicities who were living in the U.S. 1999 to 2004, including a subset of pregnant women. Exposure was defined as two or more xenobiotic blood levels at or above the geometric mean. Sexton, Olden and Johnson's modified environmental health paradigm (1993) guided the selection of 62 measures of vulnerability (susceptibility- and exposure-related attributes, socioeconomic factors and race-ethnicity).

Findings were reported for weighted (adjusted) data. The prevalence of exposures was widespread among childbearing-aged women, one fifth of whom had xenobiotic blood levels at or above the geometric mean for all three chemicals. Overall, pregnant women had lower prevalence rates. Best-fit logistic regression

exposure model contained 13 variables. Three were notable. Any fish consumption in past 30 days tripled the risk. A non-linear relationship was demonstrated with increasing age, exponential at ages 40 to 49. Past and current breastfeeding was protective for these women. Current pregnancy was protective with regard to individual chemical exposures only. Statistically significant two-way interactions were identified even though the paradigm could not be fully tested.

Further research on exposures to multiple environmental chemicals using the modified environmental health paradigm is needed. Xenobiotic biomonitoring in conjunction with risk communication among childbearing-aged women is encouraged. Precautionary level interventions aimed at eliminating or minimizing exposures are urgently needed. Bioaccumulation and transgenerational consequences of exposures should be addressed in public health policy.

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PREFACE

About the Author. Marcella Remer Thompson has a Master of Science degree in Occupational Health from the Harvard School of Public Health, a Master of Science degree in Occupational Health Nursing from Boston University and a Bachelor of Science degree *magna cum laude* from Salve Regina University in nursing. She is board certified as a safety professional and as an occupational health nurse specialist. Thompson is a Fellow of the Academy of American Occupational Health Nurses and a past recipient of the American Society of Safety Engineers (ASSE) Council on Practices and Standards' Safety Professional of the Year. Additionally, Thompson is a former ASSE Vice President of Finance and member of its Board of Directors. Her more than 25 years of work experience includes founding clinical director of a regional Boston hospital's occupational health service, consultant to small- and medium-sized businesses for occupational and environmental health and safety, principal safety engineer for a semiconductor fabrication facility and adjunct faculty for Salve Regina University in Newport, Rhode Island. Currently, Thompson is Assistant Professor, Adjunct at the College of Nursing, University of Rhode Island.

Origins of This Research. In 2004, Thompson became interested in environmental health when she was appointed by (former) Rhode Island Governor Donald E. Carcieri to Chair the Rhode Island Commission for Mercury Reduction and Education. While mercury was the focus of their efforts, it became apparent in discussions at commission meetings that there were broader environmental health issues. Through this experience, she became keenly aware that there were inequities

and gaps in the research of exposures to multiple environmental neurotoxins, particularly among women of childbearing-age. In 2005, while writing protocols for an umbilical cord blood study of lead, mercury and cadmium, there emerged one pivotal question: "Why are we waiting nine months to find out about maternal and fetal exposures to environmental chemicals?"

Future. Thompson's penultimate goals are to make a lasting contribution to the profession through mentoring future generations of occupational and environmental health and safety professionals, conducting environmental health research and improving the public's health by impacting environmental health policy, practice and actively engaging in public dialogue. Her vision for the profession includes a global perspective for managing the built environment, mastery of transdisciplinary knowledge and implementation of the precautionary principle.

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CHAPTER 1

INTRODUCTION

Women of childbearing age should be of great public health concern because their fetuses, infants and young children are vulnerable to the health effects associated with maternal exposures to certain environmental chemicals. Environmental risk factors account for 25 to 33% of the total global burden of disease (Smith, Corvalan, & Kjellstrom, 1999). Seventeen percent of all U.S.-born children are reported to have at least one neurodevelopmental disability (Boyle, Decoufle, & Yeargin-Allsopp, 1994). It is estimated that 5 to 20% of these disabilities are caused by toxic environmental exposures with annual projected costs to diagnose and treat them at $240 billion or 2.8% of all U.S. healthcare expenditures (Landrigan, Schechter, Lipton, Fahs, & Schwartz, 2002). To date, few studies have examined exposures to multiple environmental chemicals among childbearing-aged women. There is a paucity of information about population subgroups who may be disproportionately exposed and/or impacted. Additionally, these exposures may differ between pregnant and non-pregnant women.

Lead, methylmercury and polychlorinated biphenyls (PCBs) were selected for this study because they are pervasive, persistent and co-occur in the environment and each has been shown to have neurobehavioral and neurodevelopmental consequences in animal models and human population studies with these health effects occurring at concentrations below so-called “safe” levels. One would expect that the health effects

from a combination of these chemicals would be more severe than the health effects from exposure to any individual chemical.

Currently, interaction models evaluate chemicals with common health outcomes that is, neurodevelopment and/or single exposure sources such as breast milk. To evaluate the influence of binary interactions on neurotoxicity, the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) examined the scientific literature for the "mechanistic" understanding for each of these chemicals with special attention as to whether these chemicals have the same or similar toxic action.

The ATSDR estimated the direction of toxicological interaction to be greater-than-additive for methylmercury on PCBs and PCBs on methylmercury and additive for lead on methylmercury and methylmercury on lead (Agency for Toxic Substances and Disease Registry, 2004, 2006). However, limitations and inconsistencies with these models may underestimate effects of chemical interactions (Wilkinson et al., 2000). Additionally, the biologically-effective dose from exposures to multiple environmental chemicals may be lower than those associated with exposure for any single environmental chemical. To date, ATSDR has not evaluated interactions for PCBs on lead or lead on PCBs.

As specific environmental chemicals bioaccumulate, the body burden from past exposures has the potential for transgenerational consequences. As a result, childbearing-aged women – not just those who are pregnant – should be of great public health concern. In addition to bioaccumulation, these neurotoxins have adverse health effects if exposure occurs in a sensitive neurodevelopmental period during gestation. Preconceptual, periconceptual and prenatal exposures transfer to fetuses via

the placenta and to infants and young children through lactation. As a result of these transfers, there may be differences in xenobiotic (biomarker for a specific chemical) levels between pregnant or lactating and non-pregnant women.

Exposure to specific environmental chemicals is compounded by vulnerability. It is highly likely that some subgroups of childbearing-aged women have higher exposures than others. It may be possible to identify these at-risk population subgroups by susceptibility- and exposure-related attributes as well as socioeconomic factors and race-ethnicity (Sexton, Olden & Johnson, 1993a; Turner et al., 2003a). Since the health impact of exposures to multiple environmental chemicals may be greater than the impact of exposure to a specific chemical, this impact may be magnified even more among these vulnerable population subgroups. For those who are most vulnerable, a safe exposure level may be zero.

Despite what is known about the hazards of exposure to these specific environmental chemicals, little is known about exposures to combinations of these chemicals. To date, few studies have examined exposures to combinations of environmental chemicals known to have neurological and neurodevelopmental consequences among women of childbearing age.

Conceptual Framework

Exposure has been defined as "the contact between an agent and a target with contact taking place at an exposure surface over an exposure period by an exposure route" (International Programme on Chemical Safety, 2000, p. 21). Exposure is strongly related to the concepts of environment, human and health – all phenomena of interest to nursing science (Fawcett & Malinski, 1996). Exposure and health are

related to vulnerability. Vulnerability is defined most broadly as a "susceptibility to harm" (Turner et al., 2003a). Sexton, Olden and Johnson (1993a) referred to four categories of vulnerability: susceptibility-related attributes, exposure-related attributes, socioeconomic factors and race-ethnicity. It is generally thought that the more fragile, less resilient and/or less resourceful, the more vulnerable (Aday, 2001; Kasperson, 2001; Kasperson, Kasperson, Turner, Dow, & Meyer, 1995; Sexton, 1997).

In nursing, the focus is on the (human) client (Kim, 2000). As a result, exposure is measured by the presence of biomarkers in blood, tissue and body excretions. The presence of a xenobiotic (biomarker of specific chemical) or its metabolites within a compartment of an organism confirms exposure to that specific environmental substance. A biomarker of exposure reflects the relationship between external contaminant (amount available for contact from all potential sources) and body burden (internal dose). The internal dose or bioavailability of an agent is dependent upon the distribution, bioaccumulation, storage and elimination capabilities and capacities of the human body (National Research Council, 2006). Xenobiotic levels are chemical-specific biomarkers of exposure that estimate body burden most closely.

The modified environmental health paradigm (Sexton et al., 1993a, p. 714) was the overarching theoretical frame of reference and deliberative construct for this research as it described the complex relationship between the physical and biological effects of environmental hazards and vulnerability. This dissertation sought to define and explore these interrelationships.

Aim

The aim of this research was to examine childbearing-aged and pregnant childbearing-aged women's exposures to specific environmental chemicals known to have neurobehavioral and neurodevelopmental consequences in animal models and human population studies. This dissertation focused on exposures to each of these chemicals individually and in four different combinations and permutations. Additionally, this dissertation identified those population subgroups at highest risk for two or more xenobiotic (chemical-specific) blood levels at or above the geometric mean. This research used existing data from the National Health and Nutrition Examination Survey (NHANES), a national probability sample.

Research Questions. This study had three research questions:

1. What was the prevalence of childbearing-aged and pregnant childbearing-aged women's exposures to each of the following environmental chemicals: lead, methylmercury and polychlorinated biphenyls (PCBs) as measured by chemical-specific (xenobiotic) levels at or above geometric mean in blood or serum of these women who were living in the United States from 1999 through 2004?

2. What combinations and permutations of chemical exposures were most common among these childbearing-aged and pregnant childbearing-aged women as evidenced by xenobiotic blood levels at or above the geometric mean?

3. What, if any, subsets of childbearing-aged women were disproportionately exposed to two or more of these environmental chemicals based on susceptibility-related attributes (reproductive status, age, health and nutritional status), exposure-related attributes related to acculturation, proximity (residential characteristics and

occupation), activity (diet and tap water supply) and behavior (alcohol consumption and tobacco use); socioeconomic factors (education, employment, income and marital status) and race-ethnicity?

Research Design

These research questions were addressed through secondary data analysis of existing data from the National Health and Nutrition Examination Survey (NHANES), 1999 through 2004. NHANES is a population-based survey from the Centers for Disease Control and Prevention (CDC) National Center for Health Statistics (NCHS). Data from this survey are publicly available online at http://www.cdc.gov/nchs/nhanes.htm. NHANES provides a probability sample of baseline information on the health and nutritional status of the non-military, non-institutionalized adults and children living in the United States. As part of this survey, biomonitoring data was collected for more than 116 environmental chemicals or their metabolites including all the chemicals of interest to this study (Centers for Disease Control and Prevention, National Center for Environmental Health, 2007).

Significance of the Study

It is hoped that the findings of this study will help remove critical barriers to progress in areas of environmental health, public health and nursing.

By evaluating complex and important issues regarding exposures to lead, methylmercury and polychlorinated biphenyls among childbearing-aged women, environmental health research can continue with more robust study designs such as longitudinal, prospective cohort and case-control studies.

The design of NHANES allowed for this study to provide nationally representative estimates of exposures; these estimates will be useful in future public health planning. Every decade, CDC publishes its objectives for promoting health, preventing disease and eliminating health disparities in the United States. This research is relevant to CDC's *Healthy People 2020* objective EH HP2020-21: "Reduce exposure to selected environmental chemicals in the population as measured by blood and urine concentrations of the substances or their metabolites" (Centers for Disease Control and Prevention, 2009d).

This research will help provide a clearer understanding of exposure, a newly-identified concept for nursing within the client domain. By identifying at-risk groups, precautionary-level (preconceptual and prenatal) interventions can be designed and implemented. The findings of this study will support risk communication among childbearing-aged women with regard to their multiple chemical exposures and the transgenerational consequences of these exposures. *Is it safe? Is it safe enough*?

Outline of Chapters to Follow

In Chapter Two, Literature Review, definitions of exposure and related concepts are provided. Exposure models from five disciplines are reviewed. The contextual development of Sexton, Olden, and Johnson's modified environmental health paradigm is outlined and its major constructs delineated (1993a). *In vivo* and *in vitro* mechanistic interaction studies of binary chemical combinations are described. Human studies evaluating health outcomes of childbearing-aged (non-pregnant) women's exposures to these chemicals are summarized.

In Chapter Three, Methodology, the aims and research questions are reiterated. The choice of research design is discussed followed by a description of the data source that includes a brief summary of its origins. Three potential concerns involving the use of these existing data are addressed. A description of the dataset and study population are provided. Measurements of all dependent and independent variables are described; their validity and reliability reviewed. Data processing and analytic procedures are detailed. Ethical protocols used in the original research and this dissertation are outlined.

Chapter Four, Findings, begins with a general description of the study population. This chapter addresses all data gathered with regard to each research question followed by a discussion of the results. Comparisons between the exposure model and each individual chemical model are drawn and discussed.

Chapter Five, Summary, Conclusions, Limitations and Implications, summarizes the study, draws conclusions and outlines the study's limitations before outlining implications for theory development, research, education, practice and policy.

CHAPTER 2

REVIEW OF LITERATURE

In this chapter, concepts are defined. Exposure models from five disciplines are summarized. The contextual development of Sexton, Olden, and Johnson's the modified environmental health paradigm is outlined and its major constructs are delineated (1993a). In vivo and in vitro mechanistic interaction studies of three binary chemical combinations are described as are human studies that have evaluated health outcomes of exposures to all three chemicals of interest.

The Concept of Exposure

In the Oxford dictionary, exposure is defined as "an action, a state, value or condition; the action of subjecting / the state or fact of being subjected to any external influence; a definite quantity or amount of something (as in dose); an unprotected or undefended condition." To assess whether nursing had an explicit definition of exposure, a literature search was conducted using ProQuest Dissertations and Theses titles and abstracts (1997-2008) with keywords (exposure and environmental health and nursing) and CINAHL (2004-2009) with keywords (nursing and exposure and environmental health). No explicit definition or measurement of exposure was identified in nursing. It was not listed as a keyword or indexed in texts for the nursing specialties of public health, occupational health, community health or environmental health. While this concept has not been defined explicitly, it is a term that is used frequently in the nursing literature and characterized in many different ways including

causing disease, impacting a condition and adversely affecting health (Rogers, 1994b). It has been typified as a pathway or route (Lipscomb & Sattler, 2001; Institute of Medicine, 1995) and has served as an integral part of the nursing process in exposure assessment or exposure history (Sattler, Afzal, McPhaul, & Mood, 2006; Sattler, McPhaul, Afzal, & Mood, 2004). It has been given attributes of location such as occupational or residential exposure (King & Harber, 1998), hazard category for example, chemical/physical/biological exposure (Rogers & Cox, 1998), specific agent such as pesticide or lead exposure (Grady, Harden, Moritz, & Amende, 1997; Larsson & Butterfield, 2002), time as in short-term and/or long-term exposure or acute and/or chronic exposure (Edmondson & Williamson, 1998; McPhaul & Lipscomb, 2005) and a relative degree of severity as in potential or excessive toxic exposure (Sattler & Lipscomb, 2003; Tiedje & Wood, 1995).

Existing definitions and measurements of exposure were reviewed from five disciplines central to environmental health: occupational (industrial) hygiene, exposure science, toxicology, medicine and epidemiology. The disciplines of occupational (industrial) hygiene and exposure science are utilized when assessing risk (Sattler & Lipscomb, 2003). Toxicology and epidemiology are disciplines considered essential to environmental health nursing (Institute of Medicine, 1995). The review included literature identified through CINAHL, PUBMED and Sociological Abstracts as well as textbooks, dictionaries and handbooks central to these disciplines. This unpublished concept analysis (Thompson, 2006) concluded that, historically, the concept of exposure has been explicitly or implicitly defined and measured in each of these disciplines in accordance with how each discipline

approaches the etiology and amelioration of environmentally-related disease that is, source, person, outcome or some combination.

It became clear from this analysis that interdisciplinary discordance required the use of a transdisciplinary definition of exposure. A broader internet search yielded a comprehensive criteria document on human exposure assessment which was published by a transdisciplinary group of international experts from the International Programme on Chemical Safety (IPCS) under the auspices of the World Health Organization, the United Nations Environment Programme and the International Labour Organization (International Programme on Chemical Safety, 2000). They defined exposure as "the contact between an agent and a target with contact taking place at an exposure surface over an exposure period by an exposure route" (International Programme on Chemical Safety, 2000, p. 21). This is the definition of exposure that is used in this dissertation.

Exposure-Related Concepts

This concept analysis found exposure to be strongly related to the concepts of environment, human and health – all phenomena of interest to nursing science (Fawcett & Malinski, 1996). These concepts, their interrelationships with exposure and their relative importance to nursing have fluctuated over time.

Florence Nightingale believed that the environment was the fundamental cause of suffering and disease; literally, disease came "out of the air" (Nightingale, 1860). Such emphasis on the environment fell out of favor with the advent of germ theory when biological agents – not the environment itself – were identified as the cause of disease (Henle, 1840). The "patient" became "host" to these biological agents. In the twentieth century, when the interrelationship of host-agent-environment was described

as an equilibrium state, disease was no longer "a reparative process" (Nightingale, 1860, p. 7) but a state of disequilibrium. The concept of environment became inconsequential, merely "an entity in which host and agent find themselves" (Gordon, 1949, p. 507). "Health" was defined as the absence of disease. For decades, nursing constrained the definition of environment to the personal environment that is, people, places and objects that surrounded the person (Randall, Tedrow, & Van Landingham, 1984) with almost exclusive attention to the hospital or home environment and the caring of the sick. When the environment was viewed as the "source of stimuli to which individuals respond" (Chopoorian, 1986, p. 40), nursing focused on adapting the patient (as a response) to his/her environment. "Health" and "disease" were viewed more broadly on a continuous scale of well-being (Linder, 1958, p. 1276). Over time, the concept of environment encompassed socioeconomic, political and cultural aspects and institutional elements. Health, disease and well-being were considered to be biological expressions of social relations such as poverty and health disparities (Kreiger, 2001). Despite the well-publicized environmental disasters of Love Canal, Bhopal and Chernobyl, an ecological perspective of the environment was not found in community and public health nursing literature until the mid-1990s (Neufer, 1994; Tiedje & Wood, 1995).

Because a broader conceptualization of environment that encompasses global ecological perspectives has been slow to emerge in nursing, transdisciplinary definitions of environment, human and health were sought. These and other exposure-related concepts (agent, dose and vulnerability) were incorporated into one conceptual construct (Figure 1). Their definitions are provided below.

Environment. Surprisingly, "environment" was not explicitly defined in the International Programme on Chemical Safety (IPCS) criteria document on exposure assessment (2000). Kim (2000, p. 166) defined environment as "a separate entity that exists external to a person or to humanity, conceived … as that containing many distinct elements" that is, spatial, temporal and qualitative (socio-cultural). This definition of environment is congruent with IPCS definitions of target (a biological entity), agent (specific hazard) and exposure (as contact) because it allows for spatial differentiation of agent from target and therefore exposure with regard to exposure surface and exposure period. Therefore, Kim's definition of environment is used in this dissertation.

Human. Exposure is assumed to be characteristic and a process of human nature and living; by definition, an essentialistic concept in the client domain (Kim, 2000). Within this domain, there is a traditional focus on the individual as the unit of analysis. Regardless of whether the person is a single individual or an aggregate of individuals, using the target population or some segment of it as the origin of research data is an acknowledgment that the unit of analysis is at the individual level (Khrisanopulo, 1963).

Health. The authors of the IPCS criteria document (2000) did not define health explicitly. However, adverse biological effect was defined as "a change in morphology, physiology, growth, development and/or life span resulting in impairment of functional capacity to compensate for additional stress or increase in susceptibility to the harmful effects of environmental influences" (International Programme on Chemical Safety, 2000, p. 27). The phrase "to compensate for

additional stress" infers a conceptual definition of health as an outcome of successful compensation and/or adaptation to stress or stressors in the environment and, conversely, disease as an expression of failure at compensation and/or adaptation. Therefore, health was not defined in terms of a health-or-disease dichotomy but as "a continuous scale of well-being" (Linder, 1958, p. 1276). Therefore, Linder's definition of health is used in this dissertation.

Agent. "A chemical, biological or physical entity that contacts a target" (Zartarian, Ott, & Duan, 2007, p. 58) a/k/a "a threat comprised of perturbations and stress /stressors and the consequences they produce" (Turner et al., 2003a, p. 8074). An agent is referred to as a hazard if the agent is capable of causing harm. There are five general types of hazards: chemical, physical, mechanical, biological and psychosocial (Appendix B: Hazard Categories). Chemical agents in the environment are ubiquitous. There are 90 known elements and an infinite number of inorganic and organic compounds found in nature (Blumer, 1975; Turner, 2002). Some naturally-occurring chemicals and chemical compounds have been reproduced and/or modified by humans (Silbergeld, 1995). Some hazardous environmental chemicals such as lead and mercury exist naturally in elemental, inorganic and organic (e.g., alkyl lead and methylmercury) forms. However, their proportional contributions to total environmental concentrations are insignificant when compared to their anthropogenic sources (Lindberg et al., 2007). Other chemicals like polychlorinated biphenyls (PCBs) have been synthesized.

Dose. Exposure is aligned closely with the concept of dose. While exposure involves contact between an agent and a target, dose is the amount of agent that enters

a target by crossing an exposure surface or absorption barrier (International Programme on Chemical Safety, 2000). "While there can be no dose without a corresponding exposure, there can be exposure without a corresponding dose" (Zatarian, Ott & Duan, 2007, p. 45). This distinction is of paramount importance when measuring exposure and extrapolating dose. Dose equals exposure only when one assumes total absorption of the agent by the target (National Research Council, 1991). The internal dose or bioavailability of an agent is dependent upon the target's distribution, bioaccumulation, storage capacity and elimination capability (International Programme on Chemical Safety, 2000).

Vulnerability. Exposure and health are related to vulnerability. Vulnerability is defined most broadly as a "susceptibility to harm" (Turner et al., 2003a, p. 8074) with reference to physical, psychological and/or social health of individuals and/or populations (de Chesnay, 2005). The U.S. Environmental Protection Agency (2003b, p.39) defined vulnerability as "the intrinsic propensity of an exposed entity to experience adverse effects from external agents, events, perturbations or stresses." While vulnerability is variable over time at the individual level, it is more stable at the population level (Burbank, 2006). Kasperson (2001), Lee (2005), and the U.S. Environmental Protection Agency (EPA) National Environmental Justice Advisory Council (2004) have referred to four broad overlapping categories of vulnerability: susceptibility/sensitivity, differential exposure, differential preparedness and differential ability to recover. Although the term susceptibility had been used synonymously with vulnerability by the International Programme on Chemical Safety (2000), susceptibility remained a subcategory of vulnerability in this dissertation.

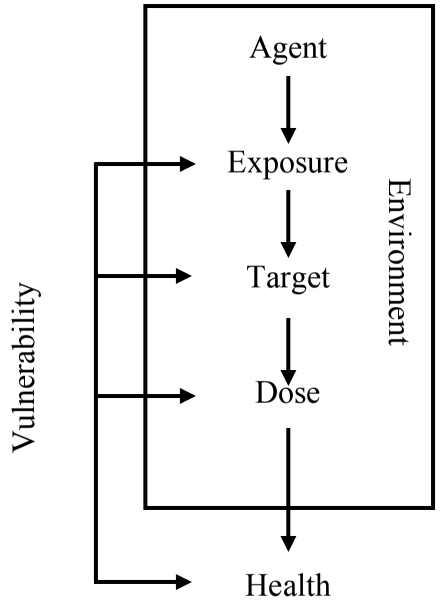


Figure 1. Exposure and Related Concepts. Adapted from *The Concept of Exposure,* by M. R. Thompson, 2006, unpublished manuscript, College of Nursing, University of Rhode Island, Kingston, RI.

Susceptibility-Related Attributes. Susceptibility or sensitivity is defined as the combination of intrinsic and acquired attributes of an individual, group of individuals or subpopulation that modify the biological response to exposure. Intrinsic attributes include genetic predisposition, gender, age and developmental stage while acquired attributes include reproductive status, health status, nutritional status and psychosocial stress or allostatic load (Grassman, 1996; Sexton, 1997). These attributes are systematically different from exposure-related attributes that increase the likelihood of exposure to environmental contaminants (Lee, 2005; Sexton, 1997).

Exposure-Related Attributes. Exposure-related attributes are acquired through differences in proximity, activity and behavior. Specifically, these attributes encompass proximity to environmental contamination sources such as residential characteristics, occupation, non-occupational activities, drinking water supply, diet and consumption of tobacco, drugs and/or alcohol (Lee, 2005; Sexton, 1997).

Socioeconomic Factors. Socioeconomic factors affect the ability to be prepared and/or to recover. Factors such as education, employment and income influence health indirectly through complex interactions with susceptibility- or exposure-related attributes or both (Sexton et al., 1993a). These interactions involve inequalities in access to adequate healthcare, nutrition, safe and healthy housing and personal, family and community resources (Flaskerud & Winslow, 1998; Mechanic & Tanner, 2007; Nyamathi, Koniak-Griffen, & Greengold, 2007).

Race-Ethnicity. The most controversial attribute of vulnerability is that of race-ethnicity. In the U.S., rates of morbidity and mortality vary significantly among racial and ethnic groups (Perlin, Wong, & Sexton, 2001; Sexton, Kleffman, & Callahan,

1995b) and the cause of these health disparities are not well elucidated (Sexton et al., 1993b). To some extent, racial and ethnic identity represents genetic and phenotypic homogeneity within a common geography and/or culture (Molnar, 1998). Sykes (2001) and others have analyzed mitochondrial DNA sequences and traced *Homo sapiens*' 150,000-year family tree to just 33 clans worldwide. While decoding the human genome and discovering epigenetic mechanisms will elucidate genetic commonalities and phenotypic distinctions (Vineis, Khan, Vlaanderen, & Vermeulen, 2009), race and ethnicity are social and not biological constructs. As such, these "bioethnic conscriptions" may act as indirect surrogates for socioeconomic disadvantage (Montgomery & Carter-Pokras, 1993; Montoya, 2007), serve as proxy variables for residential segregation and social isolation (Acevedo-Garcia & Osypuk, 2008) and/or reflect institutional environmental discrimination (Gelobter, 1992; Lee, 1992). All of these factors could influence susceptibility, exposure and health. However, even when these factors are controlled for confounding, racial and ethnic differences have persisted (Lieu, Newacheck, & McManus, 1993). Whatever the causal determinants, racial and ethnic minorities remain vulnerable and therefore, race-ethnicity was included in this dissertation.

The definition of vulnerability is congruent with the concept of health as an outcome of an adaptive process; the more fragile, less resilient and/or less resourceful, the less adaptive and consequentially, the more vulnerable (Aday, 2001; Institute of Medicine, 1995; Kasperson, 2001; Kasperson, Kasperson, Turner, Dow, & Meyer, 1995; Sexton, 1997). It is crucially important to identify those vulnerable individuals

and/or groups of individuals who are at-risk for adverse health effects as a result of exposures to multiple environmental chemicals.

Definitions for the major concepts discussed in this chapter and other exposure-related concepts can be found in Appendix C. Conceptual Definitions.

Review of Exposure Models by Discipline

Once the major concepts were defined, a review was conducted of existing exposure models in five disciplines central to environmental health: occupational (industrial) hygiene, exposure science, toxicology, medicine and epidemiology. The results of this search are summarized here.

Occupational (Industrial) Hygiene Model. The ecological model of occupational (industrial) hygiene (Cralley & Cralley, 1985) illustrates the inseparability of environment and health and describes this interrelationship as an ecological balance maintained through co-adaptation. The major assumption of this model is that man and environment are indivisible and each reacts upon the other as moving through and changing each other simultaneously (Clayton, 1973). There are three sources of environmental stressors capable of impacting health: macrocosmic stressors, microcosmic stressors and those individual stressors associated with lifestyle, work and off-the-job (Cralley & Cralley, 1985). The goal of occupational (industrial) hygiene is the protection of health through the recognition, evaluation and control of that which is both measureable and controllable in the environment (Clayton, 1973; Irish, 1973). Its central concept is surveillance with an emphasis on environmental monitoring. As a result, this model was not appropriate for this dissertation.

Exposure Science Models. Ott's (1985) full risk model is illustrated by five links from source to effect. Each link is dependent upon those links that precede it; each link is equally important in assessing overall risk.

The source-to-dose model (Lioy, 1990) begins at the point where a chemical enters the environment and tracks its movement to exposure or target contact; individual characteristics are inconsequential. Since environmental regulations seek to control specific sources of contamination, this type of model addresses each source separately. The source-to-dose model calculates exposure and potential dose for an individual within a population of interest. According to Price and Chaisson (2005), this source-to-dose model does not address aggregate exposures (total dose from a single substance received from multiple sources), cumulative exposures (total doses from multiple substances received from multiple sources), or intra- or inter-individual variation. To account for uncertainty, the model intentionally overestimates the average exposure.

The person-oriented exposure model (Price & Chaisson, 2005) places the concept of "person" at the center of the design with the focus on the population of interest rather than the sources of exposure. Price and Chaisson based their framework on a series of four nested loops which they referred to as the exposure event loop, the time-step loop, the inter-individual variation loop and the uncertainty loop. Assumptions of the model include: a chemical dose from each source is constant for a specified (short) duration of time; a chemical level in the microenvironment is constant; and person-characteristics such as physiology, demographics, housing, activities, and microenvironment are constant for a specified (short) duration of time. Distribution

sampling among the population of interest determines the person-characteristics for a specified (short) duration of time. Since the probability of exposure to each chemical source is dependent upon these person-characteristics, there appears to be a seemingly unlimited opportunity to introduce any number of human-related variables. The model allows for individuation when exposures are different, even if the chemical is the same. Exposures to multiple chemicals can be concurrent, successive or mutually exclusive. Route-specific and source-specific doses for each chemical and for each person are calculated, thus providing a more accurate population profile for a specific duration at a specific point in time. Between the exposure and inter-individual loops, the time-step loop provides insight into how a person's exposures vary over time with changes in characteristics, microenvironment and source. As a result, this model is more dynamic than the source-to-dose model. Because it is person-centered, exposure is more broadly conceptualized as a characteristically-driven process with many dimensions.

The goal of exposure science is to characterize quantitatively the relationships among all identified sources and exposure contacts with a specific target or representative population (Ott, 2007). One model is predominantly observational and performed in the field within normal living and working situations or microenvironments. The other is to construct exposure profiles mathematically (Ott, 1985). These aforementioned models of exposure were created for generalization to populations, particularly those at high risk from environmental contaminants. However, these models generate large amounts of data which could lead to "paralysis

by analysis" so there are some doubts as to their empirical application. As a result, these exposure science models were not selected for this dissertation.

Toxicological Models. There were two toxicological models examined: toxicokinetic and toxicodynamic. Toxicokinetic models trace the physiology involved with transport, metabolism and disposition of an agent internally. "What does the target do?" Toxicodynamic models describe the influence of agents on the target. "What does the agent do?" (Rozman, Doull, & Hayes, 2001).

Toxicology is the study of the adverse effects of chemicals on living organisms. It is a mechanistically-oriented discipline that identifies cellular, biochemical, and molecular mechanisms by which chemicals exert specific effects on living organisms. These mechanisms are identified through laboratory experiments and observations as well as mathematical modeling (Klaassen & Watkins, 2003). The goal of toxicology is to define dose-response, the correlative relationship between exposure and effect. Toxicology does not consider the source of exposure or the environment in which the agent exists and the target lives. Thus, these models had limited application to this dissertation.

Spectrum of Disease Model. The spectrum of disease model (Leavell & Clark, 1958) describes the prepathogenesis and pathogenesis of disease that occurs over time. The spectrum begins with the host's exposure to the etiological agent (prepathogenesis) and concludes with symptom development (pathogenesis). The spectrum encompasses subclinical manifestations of the host's response to the agent. The period of pathogenesis begins with the development of overt symptoms of illness

through the diagnosis of disease. It concludes with death, disability or recovery (Hussey, 2002).

With this model, emphasis is on diagnosis and treatment of symptoms and disease. Diagnosis involves categorization of findings from the health history, physical examination and laboratory evaluation into broad classes or so-called "toxic syndromes." Diagnosis initiates treatment for presenting symptoms based upon the most likely category of toxin responsible for those symptoms (Klaassen & Watkins, 2003.) There are many factors that confound the process of making an accurate and/or early diagnosis. Most environmentally-related illnesses either manifest as nonspecific symptoms or mimic other common illnesses in clinical presentation. Often, subclinical manifestations go unnoticed. Documenting a patient's environmental health history is rarely a routine component of primary care. It is employed only when there is already a suspicion of environmental etiology. By the time an accurate diagnosis is made, irreversible harm may have already occurred (Paranzino, Butterfield, Nastoff, & Ranger, 2005).

By emphasizing diagnosis and treatment of symptoms and disease, the spectrum of disease model is incongruent with environmental health nursing practice which focuses on the "prevention of illness and injury and protection from work-related and environmental hazards" (Association of American Occupational Health Nurses, 2008). As a result, it was not appropriate for this dissertation.

Epidemiological Models. Single causation models, multiple causation models and multi-dimensional causation models were considered.

Single Causation Models. According to miasma theory, the universal source of morbidity and mortality was the "foul emanations" from the environment (soil, water and air). A human contracted disease directly from the environment. To reduce disease, one had to control the environment (Lancisi, 1717). Germ theory identified a distinct and single *contagium animatum* responsible for each disease. To reduce disease, one had to control the infectious agent (Henle, 1840 as cited in Rosen, 1936). Gordon's (1949) epidemiological model represented interactions among host, agent and environment. To control disease, one had to maintain equilibrium among the host, agent and environment. These models have applicability to infectious and mechanical agents only. Thus, a single causation model was not appropriate for this dissertation.

Multi-Causation Models. Three multi-causation models were considered. MacMahon and Pugh (1970) broadened the single etiological model to explain how more diverse aspects of host-agent-environment were involved in disease causation. This "web of causation" model represented complex interrelationships among risk factors and disease. Cassel's (1976) psychosocial theory proposed that the host's neuroendocrine reaction to environmental stressors specifically in the social environment causes an increase in susceptibility to disease. Detrimental aspects of the social environment included dominance hierarchies, social disorganization, rapid social change, marginal status in society and bereavement. McEwen (1998) introduced the concept of "allostatic load" in which psychosocial factors were not merely contributing to an increased susceptibility to disease as Cassel had proposed, but that these reactions were directly pathogenic to the host. A combination of biological evolution, behavior and experience influences the host's perception of stress

and subsequently causes neuroendocrine stress which results in adverse health over time. These multiple causation models introduced the concept of individual susceptibility on a biological level. Inherent in this biological focus was the assumption that individual perception and behavior changes were sufficient to attain and retain health. However, there is substantial uncertainty about the relative contribution of allostatic load (Sexton et al., 1993a). These models were too limited in scope for this dissertation.

Multi-Dimensional Systems Causation Models. Three multi-dimensional systems causation models were examined. Causation models with multiple levels of interactive and dynamic systems shifted the focus from the individual to the "social production of disease" and the "political economy of health" (Krieger, 2001, p. 670). Vulnerability was viewed from a systems perspective. Krieger's (1994) ecosocial theory visualized fractals intertwined with inseparable levels of health, disease and well-being as biological expressions of social relations. "Social structure, cultural norms, ecologic milieu and genetic variability must be systematically addressed" (Krieger, 1994, p. 897). Similarly, the theory of eco-epidemiology focuses on systems analyses, specifically, pathogenesis and causality at the molecular level and causal pathways at the societal level (Susser & Susser, 1996b). In the socio-ecologic model (McMichael, 1999) interpersonal and intrapersonal aspects were illuminated to include physical, social, cultural and institutional elements such as organizational culture. These multi-dimensional systems causation models introduced the concept of sociopolitical and economically-related vulnerability. Inherent in this social focus was

the assumption that social changes on the population level were sufficient to attain and retain health. These models were too broad in scope for this dissertation.

Historically, epidemiology is defined as the study of the distribution and determinants of disease frequency and its goal is to determine the etiology of disease (MacMahon & Pugh, 1970). As such, these models were more useful in effects assessment – not exposure assessment – which was the focus of this dissertation.

Environmental Health Nursing. Salazar and Primomo's (1994) ecological systems model for environmental health nursing practice was adapted from Bronfenbrenner's (1979) ecology of human development theory. According to Bronfenbrenner's theory, an individual's environment was comprised of four concentric sets of structures (macro-, exo-, meso-, micro-systems) that reflect relative proximity or conversely, distance to/from the individual. These systems interacted through progressive mutual accommodation to shape an individual's temperament, personality, belief system and behavior (Johnson, 2002). Salazar and Primomo selected this theory because the construct of multi-dimensional systems was useful for describing the complexities of physical, cultural, social, political and economic factors that contribute to environmental hazards for application in environmental health nursing practice (Salazar & Primomo, 1994). However, their adaptation of Bronfenbrenner's theory was exploratory and, therefore, it was of limited use for this dissertation.

Conclusions. As a result of this multidisciplinary exposure models review, it was concluded that each of these models was structured in accordance with how each discipline approached the etiology and amelioration of environmentally-related

disease. These findings were consistent with findings of the concept analysis described earlier. Some of these models were congruent with conceptual definitions; none of these models addressed all key concepts. As a result of this analysis, it became clear that a single unifying conceptual framework for this dissertationn was needed – one that would address both exposure *and* vulnerability. A reference found in the IPCS criteria document on human exposure assessment (International Programme on Chemical Safety, 2000, p. 25) led to the modified environmental health paradigm (Sexton et al., 1993a).

Modified Environmental Health Paradigm

The conceptual framework selected for this dissertation was the modified environmental health paradigm by Sexton, Olden and Johnson (1993a, p. 714).

Figure 2. Modified Environmental Health Paradigm

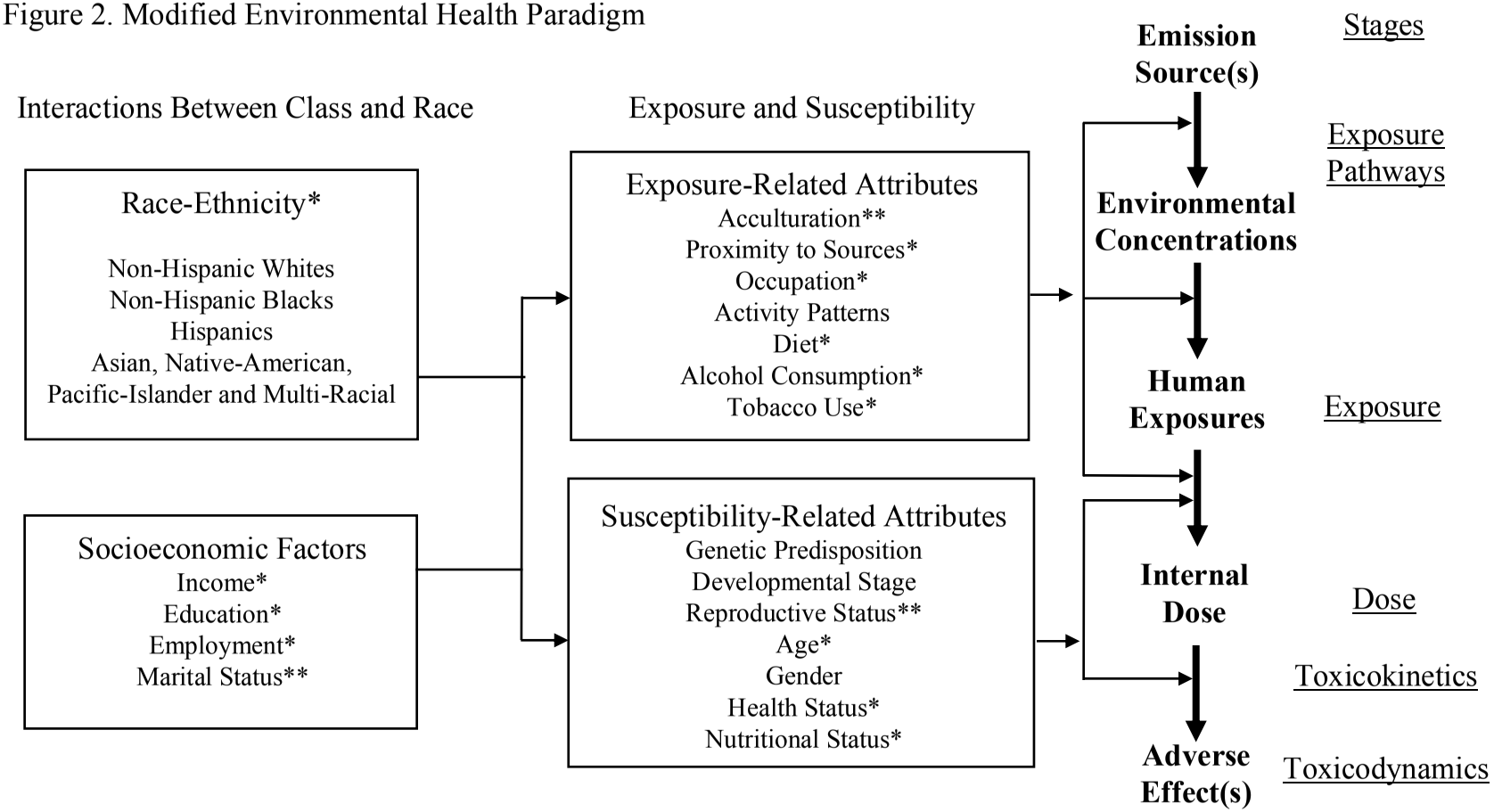


Figure 2. Modified Environmental Paradigm. bold = Original Environmental Paradigm; * = original variables; ** = variables added. Adapted from "Environmental Justice": The Central Role of Research in Establishing a Credible Scientific Foundation for Informed Decision Making, by K. Sexton, K. Olden, & B. Johnson, 1993a, *Toxicology and Industrial Health, 9*(5), p. 714. Copyright 1993 by SAGE Publications, London, UK.

Selection Criteria. Selection of this paradigm was based upon the following criteria:

1) Congruence with environmental health nursing practice which "focuses on promotion and restoration of health, prevention of illness and injury and protection from work-related and environmental hazards" (Association of American Occupational Health Nurses, 2008);

2) Focus and level of analysis is on the individual human being (Kim, 2000);

3) Addresses the essentialistic characteristics and processes of human nature and living (Kim, 2000);

4) Inclusion seven major concepts: environment, agent, exposure, target (human), dose, vulnerability and health;

5) Congruence with definition of exposure as a characteristic and process of human nature and living (Kim, 2000);

6) Conceptualization of a dynamic interactive process between/among major concepts; and

7) Incorporation of conceptual definitions consistent with all other criteria.

The following section provides historical and political contexts of its development and outlines its purpose and goals, focus, scope and basic assumptions. It includes a brief review of published research studies and critical analyses that test the theory's concepts and operational constructs.

Development of Paradigm. The historical and political context in which this framework was developed provides much insight into its philosophical foundations and construction. At the time of its original publication in 1993, Ken Sexton was

director of the U.S. Environmental Protection Agency's Office of Health Research. Barry L. Johnson was administrator of the Agency for Toxic Substances and Disease Registry and assistant surgeon general. Kenneth Olden was the director of the National Institute of Environmental Health Sciences and the National Toxicology Program, the principal federal agency responsible for assessing the toxicity of environmental substances. A decade earlier, *Risk Assessment in the Federal Government: Managing the Process* (National Research Council, 1983) had been adopted by these and other U.S. federal agencies in an effort to unify their evaluative methodologies in conducting research, assessing risks and making risk management decisions (Williams, 1995). This risk assessment process was comprised of four elements: hazard identification, exposure assessment, dose-response assessment and risk characterization (National Research Council, 1983). Health policy formulation was based upon a risk assessment's strength of evidence and the benefits and costs of different command-and-control strategies (Johnson, 2007). By employing this quantitative methodology, policy decisions were assumed to be based on "impartial" and rational choice (Bartell, 2005). Intrinsic assumptions of this process included the existence of an acceptable level of risk, the existence of a "safe" level that was possible to determine empirically and an overarching belief in the ability of biological entities to recover, if not immediately, then in the future. These policies resulted from a U.S. Supreme Court decision (Industrial Union Department v. American Petroleum Institute, 448 U.S. 607, 1980) that nullified efforts by the Occuptional Safety and Health Administration to promulgate regulations aimed at reducing occupational exposures to benzene as far as technologically possible. With this court decision,

cognizant agencies had the burden to prove harm "beyond a reasonable doubt" (Cranor, 2004). As a result, agencies' research efforts concentrated upon understanding the specific mechanisms of exposure, the determinants of health, and the links between exposure and health (Sexton & Reiter, 1989). Satisfying this fairly stringent standard of proof required detailed, science-intensive risk assessments which often combined multiple studies from the five disciplines central to environmental health.

The original environmental health paradigm (Sexton et al., 1993a, pp. 706, 719; Sexton, Callahan & Bryan, 1995a, p. 18) was conceptualized simply to represent the continuum of exposure between hazard source and health outcome and to serve as a unifying, transdisciplinary model for risk assessment (K. Sexton, personal communication, September 22, 2009). Believing that "exposure, not toxicity, is the ultimate means by which we regulate use or release of hazardous agents" (Graham et al., 1992, p. 409), risk assessment identified and evaluated adverse outcomes that could occur in well-defined scenarios resulting in narrowly-constructed hypotheses that included only well-defined variables. Unfortunately, the less defined the event or outcome, the more uncertainty existed. This epistemological uncertainty created default model assumptions which produced overly conservative risk estimates. Most often, an "uncertainty factor" or "margin of safety" ranging from 10 to 1,000 times was "calculated" into the risk assessment at the last step. Risk assessment remained a quantitative framework based on probability theory and empirical causation. It evaluated and combined evidence from various scientifically-based disciplines to determine an acceptable level of risk with which there was an associated willingness-

to-pay value (Bartell, 2005). Cost-benefit analyses of economically-related indicators provided the sole basis for determining a willingness-to-pay value associated with that risk. Another type of cost-benefit analysis used was the "quality-adjusted-life-years" calculation which compared positive outcomes with negative outcomes associated with a comparison of relative risks in terms of life expectancy. Under this original risk-based environmental health paradigm, the health policy formulation process preserved the status quo until there was sufficient certainty of evidence present or until sufficient uncertainty was removed – "innocent until proven guilty" (Cranor, 2004). To a great extent, the promulgation process remained a quagmire. The demand for strong empirical justification led to regulatory "paralysis by analysis" and a regulatory process that responded to existing health problems only when a high certainty of severe (irreversible) harm existed. If risks were small, they were considered insignificant and therefore acceptable. The goal of risk assessment was to realize the greatest good by balancing the interests of all affected persons. Risk assessment was viewed as an objective assessment of everyone's interests and a tool to guide an impartial choice to maximize good for all affected parties (Beauchamp & Childress, 2001). However, there was no independent weighting of values in the process of regulating environmental risk and that resulted unintentionally in unjust social distribution.

By 1993, there was evidence of inequitable distribution of the costs and benefits associated with environmental regulations among vulnerable communities; specifically, placement of hazardous waste sites, landfills, incinerators and polluting industries in communities inhabited mainly by racial and ethnic minorities and low

income groups (Bullard, 1990; Johnson, Harris, & Williams, 1992; United Church of Christ Commission for Social Justice, 1987; U.S. Government Accounting Office, 1983; U.S. Environmental Protection Agency, 1992a).

In 1983, the U.S. General Accounting Office (GAO) assessed the correlation between the location of hazardous waste landfills in southern states and the racial and economic status of their surrounding communities. Using 1980 U.S. census data, the GAO found African Americans were the majority population in three out of four communities and their mean family income was below that of all races within the same community. Five years later, the United Church of Christ Commission for Social Justice (1987) conducted two cross-sectional studies to determine the extent to which racial and ethnic minorities were exposed to commercial hazardous waste transfer, storage and disposal facilities (TSDFs) and uncontrolled toxic waste sites in their communities. Using racial, ethnic and income classifications from the 1980 U.S. census, their analysis indicated race was a stronger predictor of the location of TSDFs than income, education and all other socioeconomic indicators. *Dumping in Dixie: Race, Class and Environmental Quality* (Bullard, 1990) chronicled the concerns and potential health risks of those residing near hazardous waste landfills and industrial chemical facilities. This seminal work galvanized the environmental equity movement in the same way Sinclair's *The Jungle* (1906) gave impetus to food safety 84 years earlier.

In response, the Centers for Disease Control and Prevention and the Agency for Toxic Substances and Disease Registry sponsored a national minority health conference which focused on:

1. demographics (i.e., special problems in determining exposure of minority populations to hazardous substances in the environment);
2. health perspectives (i.e., factors such as nutritional status, lifestyle, and socioeconomic influences that may cause exposure to hazardous substances to affect minority populations disproportionately); and
3. health communication and health education (i.e., the effectiveness of public health messages for minority populations about preventing exposures to hazardous substances).

(Centers for Disease Control and Prevention, 1990, p. 825)

Barry L. Johnson was co-editor for the conference proceedings (Johnson, Harris, & Williams, 1992). Similarly, the EPA formed an Environmental Equity Working Group to review the impact of hazardous environmental substances on minority and low income populations. Ken Sexton was a member of this working group. *Environmental Equity: Reducing Risk For All Communities* concluded that "there are clear differences between racial groups in terms of disease and death rates" (U.S. Environmental Protection Agency, 1992a, p. 3). One recommendation was to "provide an objective basis for assessment of risks by income and race, beginning with the development of a research and data collection plan" (U.S. Environmental Protection Agency, 1992a, p. 4). This inclusion of social, economic and behavioral factors in risk assessment heralded a shift to the concept of "total risk" among populations (U.S. Environmental Protection Agency, 2003b, p. 2). It is within these contexts that Sexton, Olden and Johnson developed the modified environmental health paradigm.

Stated Purpose and Goals. "We outline a risk-based framework for analyzing issues of environmental justice … to improve our understanding of fundamental mechanisms of environmentally-related disease … and to underscore the critical

importance of identifying and evaluating groups potentially at greater risk … ” (Sexton et al., 1993a, p. 687).

Focus and Scope. The modified environmental health paradigm described the interrelationships among socioeconomic class and race, exposure- and susceptibility-related attributes and environmental health risk (Sexton et al., 1993a, p. 713.) This paradigm allowed exploration of the interrelationships among these components. Demonstrated interrelationships among socioeconomic class, race, exposure- and susceptibility-related attributes indicated whether certain demographic groups were disproportionately represented in at-risk categories. This dissertation sought to define and explore some of these interrelationships.

Theoretical and Philosophical Foundations. As stated previously, the original environmental health paradigm (Sexton et al., 1993a, pp. 706, 719; Sexton et al., 1995a, p. 18) was conceptualized simply to represent the continuum of exposure from hazard source to health outcome (“exposure-disease continuum”) and to serve as a unifying, transdisciplinary model for risk assessment (K. Sexton, personal communication, September 22, 2009). Its theoretical and philosophical foundations were post-positivistic, deduced from quantitative-based research among disciplines central to environmental health. Of note, the International Programme on Chemical Safety and other organizations selected this continuum to serve as the foundation for the domain of exposure assessment (Gee & Payne-Sturges, 2004; International Programme on Chemical Safety, 2000, p. 25; Weis et al., 2005). In an effort to explain health disparities, Sexton, Olden and Johnson modified this paradigm in 1993.

These modifications were made after careful consideration of conceptual models by Freeman, Wagener, Williams and Wilson; and Polednak.

Freeman (1989, 1991) postulated that socioeconomic factors accounted for racial differences observed in cancer incidence, mortality and survival. He cited numerous studies as evidence. Regardless of race, poor Americans had a higher incidence of cancer and lower five-year survival rates. Freeman argued that "race is a gross variable for culture, tradition, belief systems and lifestyle" and "poverty acts through this cultural prism" (Freeman, 1989, p. 329). Similar to race, poverty was a proxy variable for specific elements of living such as inadequate physical and social environments (substandard housing, social isolation); inadequate information and knowledge (lack of education); risk-promoting behaviors (smoking, alcohol consumption, substance abuse and inadequate nutrition); and inaccessible or inadequate healthcare. In his model, all of these factors contributed to decreased cancer survival.

Wagener, Williams and Wilson's (1993) model emphasized broader psychosocial contexts of environmental risks. In this model, race was a composite measure of biological, cultural, socioeconomic and sociopolitical factors as well as racial discrimination. Racial discrimination was not elaborated further. They postulated that these factors were interrelated and mitigated health status through intermediary variables such as medical care (need, access and quality); psychosocial resources (social ties, perceptions of control and coping patterns); environmental stress (residential and occupational); psychosocial stress (family, financial and residential);

and health practices (smoking, alcohol and nutrition). In turn, these intermediary variables affected health through one or more unidentified biological processes.

Polednak's (1989) model of acculturation described the interrelationships among determinants of health status and acculturation. Polednak defined acculturation as "a reciprocal process that encompasses those phenomena which result when groups of individuals having different cultures come into continuous first-hand contact with subsequent changes in the original culture patterns of either or both groups" (Polednak, 1989, p. 26). The acculturation process has four possible outcomes: assimilation (total acceptance of new culture and total rejection of the original culture); integration (partial retention of original culture with partial incorporation of the new culture); reaffirmation (total rejection of new culture and total retention of original culture); or marginalization (rejection of both original and new cultures) (Page, 2006; Maxwell, 2009). Depending upon which aspects of culture are accepted, retained or rejected, the impact of acculturation on health outcome varies (Gibson, Diaz, Mainous, & Geesey, 2005; Grant, Hamer, & Steptoe, 2009; Negy, Schwartz & Reig-Ferrer, 2009; Polednak, 1989; Weis & Bellinger, 2006).

Polednak substantiated his conceptual framework by citing many multidisciplinary studies comparing disease rates and patterns of developing countries with those countries already developed (Polednak, 1989). These studies demonstrated that improvements in sanitation, nutrition, control of infectious diseases and access to medical care have led to reductions in infant mortality and an increased average life expectancy. Conversely, increases in hypertension, diabetes mellitus, cardiovascular disease and certain cancers were the result of a combination of negative factors:

environmental (increased pollution, noise and population density); psychosocial stress (language barriers, decreased social interaction and low self-perception of health); and health practices (smoking, alcohol use, poor dietary habits, risky sexual behavior and decreased physical activity levels). This is referred to as the "immigrant paradox" where immigrant health is better upon arrival in the U.S. then declines inversely to time spent in the United States (Gallo, Penedo, Espinosa de los Monteros, & Arguelles, 2009; Lee, Nguyen, & Tsui, 2009; Markides & Coreil, 1986; Mendoza, 2009). "Both diversity and similarity across populations need to be recognized, whether one is dealing with sociocultural characteristics, biological characteristics or risk of disease" (Polednak, 1989, p. 295).

These three theories added insight into the differences in health status among racial, ethnic and socioeconomic groups and assisted Sexton, Olden and Johnson in developing their framework. However, citing "substantial uncertainty about the relative contribution of this factor" (p. 702), they chose not to address acculturation as a separate entity in their model. Despite this uncertainty, it was decided to include measures of acculturation in this dissertation as it was considered a contributing factor to exposure-related activities and behavior choices.

Basic Assumptions. Sexton, Olden and Johnson were not explicit about the assumptions for their model. Based upon readings, this author has deduced the following assumptions about the modified environmental health paradigm:

1. Human existence cannot be considered out of an environmental context (Kim, 2000, p. 167);

2. For an exposure to occur, an agent and a target must be in contact with each other, both spatially and temporally (Zartarian et al., 2007, p. 34);

3. Exposure is an integral and necessary component in a sequence of events having potential health consequences (World Health Organization, 1990, p. 23);

4. Without exposure, there can be no dose (Zartarian et al., 2007, p. 34);

5. The concentration of each agent generated from each source and the resulting dose are constant for a specific period of time (Zartarian et al., 1997);

6. Vulnerability increases the risk of adverse health effects from a given exposure (Sexton et al., 1993a); and

7. Vulnerability impacts compensation and recovery from these adverse health effects (Sexton, 1992b).

Tests for Validity and Reliability. The original environmental health paradigm by Sexton, Olden and Johnson is widely accepted. The International Programme on Chemical Safety and the Environmental Protection Agency selected the original environmental health paradigm to serve as the foundation for exposure assessment and human health environmental exposure research (International Programme on Chemical Safety, 2000, p. 25; U.S. Environmental Protection Agency, 2003c). It has been used by various investigators and organizations to conceptualize their research directions and strategies (K. Sexton, personal communication, October 13, 2009). Twelve articles referencing Sexton, Olden and Johnson's paradigm were identified using the keywords (environmental health paradigm and Sexton or Sexton) in CINAHL, PUBMED, Sociological Abstracts and the ProQuest Dissertations and Theses database (1993-2009). These publications were reviewed. Only one by

Murray (2003) specifically evoked the modified environmental health paradigm. To date, no known tests for validity and reliability have been performed on this paradigm.

Relational Propositions. The original environmental health paradigm consists of five stages: exposure pathways, exposure, dose, toxicokinetics, toxicodynamics. Vulnerability was added in the modified version. These relationships are delineated here within the context of this study's three chemicals of interest: lead, methylmercury and PCBs and a review of the scientific literature.

Stage One: Exposure Pathways. There are three possible exposure pathways that an agent takes from its source to the target:

1. directly from the sources via one or more environment media;
2. indirectly after undergoing transformation by biotic or abiotic means; and
3. accumulating in the environment (Lioy, 1990).

When quantifying exposure pathways, data are collected non-invasively through chemical inventories, environmental monitoring and personal monitoring as an agent's concentration in a particular medium. Measurement of specific agents in a target's environment establishes whether and to what extent the individual is potentially exposed to such agents. Fate and transport models identify and evaluate exposures most accurately when specific agents, sources and concentrations of agents, and exposure pathways are known a priori such as in occupational settings (Price & Chaisson, 2005).

Lead, methylmercury and PCBs are pervasive, persistent and co-occur in the environment. Because of the hemispheric distribution of global emissions, these chemicals have been detected at elevated levels in all remote areas of the globe. For

example, lead has been found in Icelandic salt marshes (Marshall, Clough, & Gehrels, 2009; Shotyk & LeRoux, 2005), mercury in the tundra ecosystem (Poissant, Zhang, Canario, & Constant, 2008), and PCBs in Arctic and Antarctic air (Choi et al., 2008). Even if it were possible to cease all new emissions of these chemicals, their biogeochemical cycles would extend for years to decades or longer (U.S. Environmental Protection Agency, 2008a). Their environmental persistence is affected by air and sea temperatures, wind speeds, variation in precipitation patterns (Lindberg et al., 2007) and secondary effects of climate change (McMichael & Martins, 2002) such as soil acidification (Navratil, Skrivan, Vach, Dobesova, & Langrova, 2004). Irrespective of source, it is generally accepted that co-occurrence of environmental chemicals in general and these chemicals in particular exist due to their common spatial and temporal distributions (Altenburger, 2008; Agency for Toxic Substance and Disease Registry, 2004, 2006). As a result of this pervasiveness, persistence and co-occurrence, humans have daily contact with these three environmental chemicals. They are present at or above detectable levels:

1. in air, water, soil/rock and food (Clayton, Pellizzari, Whitmore, Perritt, & Quackenboss, 1999; Kawahara, Horikoshi, Yamaguchi, Kumagai, & Yanagisawa, 2005; Sunderland, 2007; Macintosh, Kabiru, Echols, & Ryan, 2001; Mahaffey, Clickner, & Bodurow, 2004; Roy, Georgopoulos, Ouyang, Freeman, & Lioy, 2003; Schecter et al., 2001);
2. where people live, work, play and learn (Herrick, McClean, Meeker, Baxter, & Weymouth, 2004; Herrick, Meeker, Hauser, Altshul, & Weymouth, 2007;

Krieger, Bernard, Dinoff, Ross, & Williams, 2001; Lauwerys & Hoet, 1993; Lawson et al., 2006; Rudel, Seryak, & Brody, 2008; Van Hemmen et al., 2001);

3. in consumer products purchased and equipment used (MacGregor, 2004; McRill, Boyer, Flood, & Ortega, 2000; Sällsten, Thorén, Barregård, Schütz, & Skarping, 1996; Weldon et al., 2000); and,

4. in some instances, these chemicals are incorporated into social behaviors and ritual practices (JSI Center for Environmental Health Studies, 2003; Riley, Newby, Leal-Almeraz, & Thomas, 2001; U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, 2002).

Stage Two: Exposure. There may be multiple and/or sustained contacts with one or more agents. An exposure assessment estimates the exposure concentration for an individual. Such an assessment assumes that the concentration of agent generated from each source is constant for a specified duration of time (Zartarian et al., 1997). Since a target's specific activities affect exposure, measures of contact can be based on activity patterns from diaries, questionnaires and direct observation (International Programme on Chemical Safety, 2000). While adding a time-step loop may provide insight into intra-individual variation, it does not address inter-individual variation adequately. A large population sample is required to compensate for these variations (Price & Chaisson, 2005). This dissertation used a large population sample.

Stage Three: Dose. The amount of agent that enters a target in a specified time duration after crossing an exposure surface and/or absorption barrier is a function of the exposure concentration (International Programme on Chemical Safety, 2000). The rate and extent to which an agent can be absorbed by a target is dependent upon the

agent-in-medium's molecular weight and chemical properties specifically, pH, degree of ionization, water or lipid solubility and the target's physiology. Lead, methylmercury and PCBs are lipophilic and unbound to plasma protein and, as such, either simply diffuse across or are transported through an absorption barrier by specialized carrier systems (Dix, 2001). Absorption of an agent can be impacted by pre-systemic ("first-pass") extraction whereby some or all of it is eliminated quickly (Eaton, 2005).

Stage Four: Toxicokinetics. Once the agent is absorbed, it is subject to a myriad of toxicokinetic processes involving distribution, bioaccumulation and elimination (International Programme on Chemical Safety, 2001a). Distribution of the agent among anatomical or physiologic compartments via systemic circulation that is, blood and/or lymph, may or may not result in different concentrations of xenobiotics in various tissues and/or organs over time. Distribution is dependent upon volume and clearance, the agent's affinity for the medium and the target's elimination efficiency. Toxicokinetic mechanisms that may be affected include enzyme and active transport induction, competitive inhibition, modification of uptake and elimination (Sexton & Hattis, 2007). In a single-compartment model, the xenobiotic equilibrates quickly in all body tissues that is, xenobiotic concentrations and subsequent changes in concentrations are proportional throughout the body even though the concentrations may not be identical numerically. The elimination rate is linear and affected by dose and the limits of the target's capacity to respond (Medinsky & Valentine, 2003). In a two-compartment model, there are central compartments (blood/plasma/lymph) and peripheral compartments (tissues). Distribution is rapid but concentrations are not

proportional between compartments. Elimination rate is slower and independent of dose (Caraccio & Mofenson, 1993).

Exposure, dose and these toxicokinetic processes determine the body burden. Repeated exposures to an agent result in cumulative storage and a corresponding increase in body burden until a steady state is achieved (Dix, 2001, p. 569). An agent with a long biological half-life bioaccumulates with each successive dose, reaches steady-state concentration slowly and continues to be excreted slowly even after exposure has ceased (Medinsky & Valentine, 2003). Plasma proteins, fat tissue, bone and organ systems that are responsible for elimination (liver, kidney) store these xenobiotics. The agent is released very slowly from these storage sites as it undergoes biotransformation and excretion (Rozman & Klaassen, 2003).

A biomarker of exposure reflects the relationship between external contaminant (i.e., amount available for contact from all potential sources) and body burden (i.e., internal dose). Biomarkers of exposure do not provide information on timing, sources or routes of exposure. While timing and duration of exposure are more critical for chemicals with shorter half-lives, it is less critical for those with longer half-lives as is the case with lead, methylmercury and PCBs. For agents that produce developmental defects at low dosages or concentrations, biomarkers may be the only available indicators of exposure (National Research Council, 2000a). Xenobiotic levels are chemical-specific biomarkers of exposure that estimate body burden most closely. It is for these reasons that xenobiotic levels in blood were used to assess exposures in this dissertation. Exposures to multiple environmental chemicals could produce any one of four toxicokinetic interactions: independence, antagonism, additivity or

synergism (Appendix C: Conceptual Definitions). Chemical interaction models are addressed further in this chapter.

Stage Five: Toxicodynamics. At the molecular level, an agent biochemically alters the target's cell regulation and/or cell maintenance. If and when the degree and rate of the target's compensatory biochemical mechanisms are absent, insufficient and/or overwhelmed, then cellular dysfunction, dysregulation and/or destruction at the tissue, organ and/or organism level results (International Programme on Chemical Safety, 2001b). A target's response can be measured in biomarkers of effect and detected as subclinical and/or clinical manifestations of morbidity and mortality.

Exposure to any one of these three chemicals has been shown to have neurobehavioral and/or neurodevelopmental consequences in animal models and human population studies (Collaborative on Health and the Environment's Learning and Development Disabilities Initiative, 2008a, 2008b). These effects are well documented and have been reviewed elsewhere (Costa, Aschner, Vitalone, Syversen, & Soldin, 2004; Faroon, Jones, & deRosa, 2000; Wigle et al., 2007).

For each dose response, there should be a corresponding conceptual biological plausibility that may or may not be understood fully. The correlative relationship between dose and a defined response can be graphically depicted as *s*-curved or biphasic (Calabrese & Baldwin, 2003). A biphasic or hormetic response may reflect data variability (Thayer, Melnick, Burns, Davis, & Huff 2005) or the presence of two or more different biochemical mechanisms with parallel or non-parallel overlapping dosages (Rozman, Doull, & Hayes, 2001). The slope of a dose response relationship may or may not be constant. An inconsistent slope may reflect two or more different

biochemical mechanisms as well. Most importantly, a low or no-dose threshold may reflect a target's vulnerabilities more than an agent's toxicity. Several epidemiologic studies have indicated that health effects occur at concentrations below "safe" levels (Grandjean, Budtz-Jørgensen, Kieding, & Weihe, 2004a; Lanphear, Dietrich, Auinger & Cox, 2000) with a cumulative impact on health (Sexton & Hattis, 2007). The degree to which a target is likely to experience "harmful effects of environmental influences" results from the intersection of an agent's toxicity and the target's vulnerability (International Programme on Chemical Safety, 2000, p. 27).

Vulnerability. There are four components to vulnerability: susceptibility-and exposure-related attributes, socioeconomic class and race-ethnicity. Vulnerability can influence the magnitude of biological response to environmentally-related exposures, the type of response or both (Grassman, 1996; Sexton, 1997). The health effects of vulnerability may be cumulative (Nyamathi, Koniak-Griffin, & Greengold, 2007; Shi & Stevens, 2005; Shi, Stevens, Lebrun, Faed, & Tsai, 2008).

Susceptibility-Related Attributes. These attributes are comprised of intrinsic and acquired attributes that modify the response to exposure. Intrinsic attributes are physiologic in nature and include genetic predisposition, developmental stage, age and gender. Acquired attributes include health status and nutritional status (Grassman, 1996; Sexton, 1997; Sexton et al., 1993b).

Genetic Predisposition. Certain interactions among genes, proteins and metabolites may modify biologic response to environmental exposure (Cascorbi, 2006; Neri et al., 2006). Human epidemiological and animal studies have demonstrated associations between genetic variations, phenotypic expressions and

disease etiologies (Cummings & Kavlok, 2004). Current understanding of the gene-environment interactions involved in toxicokinetics are rudimentary (Gundacker, Gencik, & Hengstschläger, 2010). Few population studies include biomarkers of susceptibility. As a result, this type of intrinsic susceptibility was not included in this research.

Developmental Stage. Fifty percent of all females living in the United States are of childbearing-age (U.S. Census Bureau, 2000). Since these specific environmental chemicals bioaccumulate, the body burden from past exposures has the potential for transgenerational consequences. In addition to bioaccumulation, these neurotoxins have adverse health effects if exposure occurs in a sensitive neurodevelopmental period during gestation. During pregnancy, environmental chemicals are easily transferred from maternal blood through the placenta to the fetus by simple diffusion since the placenta is a permeable plasma membrane (Goyer, 1990). Since the blood-cerebrospinal fluid-brain barrier does not mature until the infant is six months old, plasma proteins easily transfer through this "barrier" to the developing brain (Adinolfi, 1985). There exists structural and functional windows of vulnerability during which environmental exposures have the potential to alter neurodevelopment and neurobehavior permanently (Wilson, 1973). On a cellular level, crucial stages of neurodevelopment include: neuronal and glial proliferation, neuronal and glial differentiation, cellular migration, neurite outgrowth of axonal and dendrite processes, synaptogenesis (formation of neurotransmitters and receptors), myelination and apoptosis or programmed cell death (Radio, Freudenrich, Robinette, Crofton, & Mundy, 2010; Suñol, 2010). All of these stages occur with precision timing during

the prenatal period with connectivity and synaptic reorganization occurring into adolescence (Connors et al., 2008). Xenobiotic disruption of neurodevelopment may occur at one or more of these morphological and/or functional maturational stages. Further detail regarding these specific mechanisms is beyond the scope of this dissertation.

Reproductive Status. Preconceptual, periconceptual and prenatal exposures to these chemicals transfer to fetuses via the placenta and umbilical cord, and to infants and young children through lactation (Axelrad, Bellinger, Ryan, & Woodruff, 2007; Bellinger, Leviton, Waternaux, Needleman, & Rabinowitz, 1987; Daniels et al., 2003; Dewailly et al., 1996; Gundacker et al., 2002; Pilsner et al., 2009;Vreugdenhil, Van Zanten, Brocaar, Mulder, & Weisglas-Kuperus, 2004). As a result of these transfers, there may be differences in xenobiotic blood levels between pregnant and non-pregnant women.

Age. Susceptibility is age-dependent. An infant's rapid respiratory rate and higher skin permeability increases the amount of agent inhaled or absorbed while those agents ingested through lactation diffuse freely through gastrointestinal mucosa into blood circulation to target organs (Weiss & Bellinger, 2006). The endocrine, reproductive, immune, visual and nervous systems are particularly vulnerable (Butterfield, 2002). Children absorb a larger dose per unit of body weight. Functional immaturity of the liver and kidneys lowers the ability to metabolize and eliminate certain agents (Bruckner, 2000). With aging, subtle changes in synapses, receptors, neurotransmitters and other mechanisms can lead to cognitive dysfunction (Shankar, 2010). There are structural and functional changes in the liver and kidney as well

(Cory-Slechta, 1990; Esposito & Dal Canton, 2010). Loss of bone mineral density (Theppeang et al., 2008) and changes in body fat composition (Mitchell, Haan, Steinberg, & Visser, 2003) may increase xenobiotic blood levels.

Health Status. Health status is multidimensional and dynamic, incorporating physical and mental well-being as well as recovery capability (Robine, Jagger, & Egidi, 2000). Co-morbid disease adds prognostic burden to exposure outcomes by impacting toxicokinetic and toxicodynamic processes. Conversely, environmental exposures may exacerbate pre-existing disease conditions (Herzstein, 2005). Inadequate access to healthcare may delay diagnosis and treatment of environmentally-related disease (Sexton, 1997).

The ability to recover and/or maintain health is closely tied to access and use of healthcare and social services (Lee, 2000). In the United States, a lack of health insurance is responsible for approximately 18,000 unnecessary deaths annually (Institute of Medicine, 2004). For the most part, health insurance coverage in the United States is provided to an individual and/or an individual's immediate family through the private sector (typically employer-based) or government-funded programs. Those who do not qualify for health insurance benefits are unemployed, employed part-time or engaged in seasonal or temporary work. Others cannot afford insurance premiums, copayments and co-insurance fees. One in five childbearing-aged women are uninsured (U.S. Census Bureau, 2009).

Nutritional Status. Nutritional balance is important to overall health. Mineral, vitamin and/or protein deficiency leads to dysfunction, disease and/or impaired recovery from illness or injury (Morón & Viteri, 2009). Some micronutrients prevent

bioactivation of specific environmental agents and conversely, some agents can impair the bioavailability of micronutrients (Ralston, Ralston, Blackwell, & Raymond, 2008; Twaroski, O'Brien, & Robertson, 2001). Mineral and elemental deficiencies can result in increased absorption of specific environmental chemicals (Soeters et al., 2008). Deficiency in iron and calcium may increase absorption of lead (Kwong, Friello, & Semba, 2004). Selenium can inhibit absorption of methylmercury (Ralston, Ralston, Blackwell, & Raymond, 2008). The lipophilic chemical body burden is related to total body fat. When weight loss, vigorous physical activity, pregnancy or lactation mobilizes fat stores, lipophilic chemicals are released into the blood (Herzstein, 2005). Food insecurity or the lack of enough nutritious food has been related to increased risk of fair or poor child health (Chilton et al., 2009) and depression and poor health in adults (Chilton & Rose, 2009).

Exposure-Related Attributes. These attributes are acquired through differences in proximity, activity and behavior (Lee, 2005; Sexton, 1997). These exposure-related attributes are systematically different from susceptibility-related attributes because they increase the likelihood of exposure to environmental contaminants.

Acculturation. As discussed previously in this chapter, since acculturation is considered to be a contributing factor to exposure-related activities and behavior choices, acculturation was included in this dissertation.

Proximity to Sources. "Built" environments (e.g., residences, schools and workplaces) are primary sources of environmental contaminants. Statistical relationships have been found among race, poverty, age and residential proximity to industrial sources of pollution (Perlin, Wong, & Sexton, 2001). Relative proximity to

stationary sources (e.g., industries, landfills and hazardous waste sites), increases the likelihood and magnitude of exposure (Aelion, Davis, McDermott, & Lawson, 2009). The degree of environmental contamination has been correlated with population density as well as industrial and agricultural intensity (Schwela, 2000). Sixty-eight percent of the U.S. population lives within an urbanized area with a population density of 50,000 people or more (U.S. Census Bureau, 2000). Models predict North American urban intake fractions to be one order of magnitude higher than rural intake fractions (Humbert et al., 2009).

Americans spend 87% of their time indoors in residences, schools and workplaces with an additional 5% spent in transit (Klepeis et al., 2001). Indoor environmental contaminants have been estimated to be 1,000 times more likely to result in exposure than outdoor sources (Ilacqua, Hanninen, Kuenzli, & Jantunen, 2007) and persist over longer periods of time (Carpi & Chen, 2001). As a result, this dissertation addressed indoor sources of exposure only.

Sixty-nine percent of all occupied housing units are owner-occupied with 79% as single-family homes (U.S. Census Bureau, 2000). Housing quality has been shown to be correlated with environmental contaminant levels (Jacobs, Wilson, Dixon, Smith, & Evens, 2009). Continuous contamination sources include emissions from building materials with intentional agent additives (e.g., lead and methylmercury in paint, PCBs in piping and caulking) or unintentional contaminants such as lead dust or airborne PCBs and mercury (Harrad, Hazrati, & Ibarra, 2006). Discontinuous contaminated sources are associated with smoking and household maintenance such as cooking, cleaning and vector control agents (Whyatt et al., 2003). Even though lead in new

house paint was banned in 1978 (U.S. Environmental Protection Agency, 2010a), PCB manufacturing was banned in 1979 (U.S. Environmental Protection Agency, 2009d), and mercury in new latex paint was banned in the early 1990s (Weschler, 2009), these three chemicals can be found in most older homes. Agocs et al. (1990) measured potentially hazardous levels of mercury in homes painted with interior latex paint. In 2002, a cross-sectional study by Kim, Staley, Curtis, and Buchanan found a direct correlation between the age of the house and the mean blood lead level of resident children. And in 2004, Herrick, McClean, Meeker, Baxter and Weymouth found extensive PCB contamination in schools and other buildings. This study used age of residence as an indicator of potential environmental chemical contamination.

Occupation. Each workplace and each occupation has both a commonality to product and process and a unique combination of hazards, varying potential for exposures and a continued risk for injury or illness or exacerbation of a pre-existing injury or illness. A working population is generally healthier than the overall population, so prevalence rates of disease conditions may differ between these two groups. Those employees most affected by an acute occupational exposure will most likely request transfer to a different position or self-terminate employment. This is referred to as the "healthy worker effect" (Monson, 1980). Adults spend 24 to 36% of their time at work. A working lifetime spans many decades and, as such, working adults are more likely to experience long-term health effects from lower levels of exposures to environmental contaminants. Many reproductive toxicants are found in traditionally female-dominated employment sectors specifically, healthcare and service (McDiarmid & Gehle, 2006). Minorities represent 28% of the workforce.

Hispanic men and African-American women represent the largest subgroups of minority workers (Lusk, Connon, Dirksen & Miller, 2001). Minorities are employed disproportionately in high-risk occupations and they hold lower paying jobs than Non-Hispanic White coworkers (U.S. Census Bureau, 2003b). While past veteran/military service may present a potential source of exposure, it was not included in this study. Additionally, all military personnel were excluded from participating in the NHANES survey.

Activity Patterns. Those exposure-related attributes associated with activity include recreational or subsistence hunting and/or fishing and vigorous physical activity (Lee, 2005; Sexton, 1997). Non-occupational or recreational activities such as hunting and fishing are potential sources of environmental chemical exposure if what is hunted and caught is contaminated and consumed. Immigrant, poor and indigenous populations are known to engage in subsistence fishing and hunting (Dellinger, 2004; Mariën & Patrick, 2001; Tsuji et al., 2008; Weintraub & Birnbaum, 2008). While these activities may be important sources of exposure among certain population subgroups (Dellinger, 2004; Mariën & Patrick, 2001; Tsuji et al., 2008; Weintraub & Birnbaum, 2008), this variable could not be included in this study because the number of study participants engaged in these activities was too small. Vigorous physical activity can mobilize fat stores, thus releasing lipophilic chemicals into the blood (Herzstein, 2005). Physical activity was not included in this study.

Those exposure-related attributes associated with behavior include diet, drinking water supply, alcohol consumption and tobacco use (Lee, 2005; Sexton, 1997).

Diet. Domestic and imported produce, meats, dairy, seafood and freshwater fish are primary sources of these environmental chemical exposures for adults (Clarkson, Amin-Zaki, & Al-Tikriti, 1976; Curley et al., 1971; Dórea, 2008; Mahaffey, Clickner, & Jeffries, 2009; Schecter & Piskac, 2001; Stewart et al., 1999). These persistent chemicals biomagnify in wild piscivorous fish, mammals and birds at relatively higher levels than non-predatory species with intraspecies variability occurring with habitat diversity (Scheuhammer, Meyer, Sandheinrich, & Murray, 2007).

Drinking Water Supply. Drinking water becomes contaminated as a result of industrial effluent, agricultural runoff, sewage treatment discharge, storm water, urban street runoff, atmospheric deposition, naturally-occurring inorganic and organic substances and residential water delivery systems (Ritter et al., 2002). Municipalities are required by the U.S. Environmental Protection Agency to test potable water for certain environmental chemicals and to initiate proper mitigation procedures when maximum contaminant levels are exceeded (U.S. Environmental Protection Agency, 2009c). However, this does not address lead and PCB contamination from water delivery systems inside residences or private-owned drinking water sources (Kim & Herrera, 2010; Palmer, Wilson, Casey, & Wagner, 2010). Fifteen percent of the U.S. population may be at increased risk for environmental chemical exposure since they rely on privately-owned drinking water sources not regulated by the EPA. Commercially available water treatment devices may remove some but not all contaminants (U.S. Environmental Protection Agency, 2002).

Alcohol Consumption. The prevalence of alcohol consumption among U.S. childbearing-aged women is 53% (Tsai & Floyd, 2004). Of those women surveyed,

29% reported consuming an average of five or more drinks on typical drinking days and 12% reported binge drinking. On average, 21% consumed 45 drinks per month (Tsai, Floyd, Green, & Boyle, 2007). Since the liver is the primary organ of detoxification and elimination by metabolism of many chemicals, interaction between alcohol and an environmental chemical may be toxicokinetic or toxicodynamic (Alessio, Apostoli, & Crippa, 1995; Mumenthaler, Taylor, & Yesavage, 2000; Toffoletto, Crippa, & Torri, 2007). Alcohol impairs two micronutrients important to fetal development: folate (Hamid, Wani, & Kaur, 2009) and calcium (Nagy, 2000). Increasing frequency of drinking in late pregnancy has been associated with increasing umbilical cord blood lead levels relative to maternal blood lead levels (Harville et al., 2005). Additionally, alcohol consumption has been associated with increased concentrations of PCBs in breast milk fat (Dewailly et al., 1996). Alcohol potentiation of prenatal methylmercury- and lead-related toxicities has been demonstrated in animal studies (Gupta & Gill, 2000; Turner, Bhatnagar, & Yamashiro, 1981; Maia et al., 2009a), but not of PCBs (Krampl, Kontskova, & Kramplova, 1980). However, PCBs have been shown to be hepatotoxic in animal studies (Agency for Toxic Substances and Disease Registry, 2000).

Tobacco Use. In 2000, 21% of U.S. women smoked cigarettes (Trosclair, Husten, Pederson, & Dhillon, 2002). More women than men are exposed to environmental tobacco smoke that is, "secondhand smoke" (Wipfli et al., 2008). Tobacco contains over 400 identified chemical compounds (Kutlu, Karagozler, & Gozurkara, 2006) including nicotine, cadmium, lead, chromium, nickel (Pereg, Lagueux, DeWailly, Poirier, & Ayotte, 2001) and dioxin-like PCBs (Uehara,

Nakamura, Matsuura, Kondo, & Tada, 2007). Blood lead levels increase with both active and passive smoking (Kutlu, Karagozler, & Gozurkara, 2006; Willers, Gerhardsson, & Lundh, 2005). However, smoking has been associated with decreased levels of dioxin-like PCBs (Uehara et al., 2007). When cigarettes become contaminated through airborne deposition of chemicals and/or insufficient handwashing, secondary inhalation of environmental chemicals can occur as well (Askin & Volkmann, 1997).

Socioeconomic Factors. These factors affect the ability to be prepared and/or to recover. Factors such as education, employment and income influence health indirectly through complex interactions with susceptibility- or exposure-related attributes or both (Sexton et al., 1993a). These interactions may result in inequalities in safe and healthy housing, nutritional status, health status and risk-related behaviors (Flaskerud & Winslow, 1998; Mechanic & Tanner, 2007; Nyamathi et al., 2007).

Education. In 2000, 81% of all U.S. women had completed high school and approximately 23% had earned a bachelor's degree (Bauman & Graf, 2003). Higher educational attainment has been associated with better physical health (Winkleby, Jatulis, Frank, & Fortmann, 1992; Zajacova & Hummer, 2009). Johnson et al. (2009) speculated that more educated people may manage their environments better to protect their health. Health literacy may influence one's ability to make healthcare-related decisions (Smith, Trevena, Nutbeam, Dixon, & McCaffery, 2009). Overall, education is viewed as the key to increased opportunities for employment and higher income potential (Adler & Newman, 2002).

Employment. In 2000, 50% of all childbearing-aged women worked (Clark & Weismantle, 2003). Of these women, 50% worked usually fewer than 35 hours per week and 5.5% held more than one job (U.S. Bureau of Labor Statistics, 2005). When workers become unemployed, their health is likely to suffer. Based on data from the U.S. Panel Study of Income Dynamics (1999-2003), involuntary job separation increased the odds of reporting fair or poor health by 56% and the odds of reporting a new health problem by 84%, regardless of race-ethnicity (Strully, 2009). However, with voluntary job separation, the odds of reporting fair or poor health increased to 84% for Non-Hispanic Black and Hispanic respondents as compared to Non-Hispanic White respondents. It was not possible to determine whether poor health was the primary reason for voluntary job separation. Gender differences were not examined. In 2002, the unemployment rate was 9.5% for mothers who were single, widowed, divorced or separated with children under 18 years – twice that of married mothers of similar age with children under 18 years (U.S. Bureau of Labor Statistics, 2003). Among women, unemployment has been associated with increased tobacco use (Novo, Hammarström, & Janlert, 2000) but not increased alcohol consumption (Gore, Harris, & Firestone, 2004).

Income. In 2000, 17% of women aged 18-64 and 36% of female heads-of-household with children under 18 had incomes below the federal poverty threshold (U.S. Census Bureau, 2008). Women comprise more than 61% of minimum wage workers (Lichtenwalder, 2005). Mortality and morbidity rates as well as self-assessments of poor health are substantially higher among the poor (Lu, Samuels, & Wilson, 2004; Mackenbach et al., 2008; Montgomery & Carter-Pokras, 1993) and

especially poor women (Nagahawatte & Goldenberg, 2008). Larson and Halfon (2009) determined income was strongly and significantly related to health outcomes in children. The percentage of children in poor health increased with decreasing family income for 15 health indicators with the steepest income-to-health gradient at 100% below the federal poverty level.

Marital Status. While this variable was not included in the modified environmental health paradigm, marital status is an important socioeoconomically-related factor for women and their overall health (Schoenborn, 2004; Skalická & Kunst, 2008; Wickrama et al., 2006). As a result, it was included in this dissertation.

Race-Ethnicity. Health disparities among racial and ethnic minorities are well known (Morello-Frosch & Lopez, 2006a; Morello-Frosch & Shenassa, 2006b; Payne-Sturges & Gee, 2006). As stated previously, there is considerable evidence of inequitable distribution of the costs and benefits associated with environmental regulations among vulnerable communities. The placement of hazardous waste sites, landfills, incinerators and polluting industries is more common in communities inhabited mainly by low income groups and racial and ethnic minorities (Bullard, 1990; Johnson, Harris, & Williams, 1992; Mohai, & Bryant, 1992b; United Church of Christ Commission for Racial Justice, 1987; U.S. Government Accounting Office, 1983; U.S. Environmental Protection Agency, 1992a). Race-ethnicity may serve as proxy variables for residential segregation and social isolation (Acevedo-Garcia & Osypuk, 2008) and/or reflect institutional environmental discrimination (Gelobter, 1992; Lee, 1992). Each of these factors could influence susceptibility, exposure and health (Merkin et al., 2009).

This concludes a description of the major constructs of the modified environmental health paradigm upon which this dissertation was based. The last section of this chapter will return to the toxicokinetic and toxicodynamic stages for a review of the scientific literature pertaining to *in vivo* and *in vitro* mechanistic studies of binary chemical interactions and human studies related to exposure to all three chemicals.

Chemical Interaction Models

Despite what is known about the hazards of exposure to these specific environmental chemicals, the health effects from exposures to combinations and permutations of these environmental chemicals and their corresponding biologically-effective dose are relatively unknown. One would expect them to be more severe than those from exposure to a single specific chemical.

The U.S. Agency for Toxic Substances and Disease Registry (ATSDR) developed interaction models to evaluate chemicals with a common target site such as neurodevelopment or a single exposure source such as breast milk. To estimate the influence of binary interactions on toxicity, their meta-analyses assessed the "mechanistic" (chemical-chemical, toxicokinetic, toxicodynamic) understanding of the interaction, the toxicological significance of the interaction, the presence of any modifiers (i.e., route of exposure, exposure duration and sequence) and existing *in vivo* and *in vitro* data (Agency for Toxic Substances and Disease Registry, 2001; Mumtaz & Durkin, 1992). The endpoint of analysis was a binary weight-of-evidence (BINWOE) score as a weighted factor and an estimate of the direction of interaction (Appendix D: Assessing Chemical Interactions). Limitations of this modeling include

analyses of binary interactions only (Callahan & Sexton, 2007) and the general lack of data quality weighting factors (Monosson, 2005). Both of these limitations may underestimate the effects of these chemical interactions (Chen et al., 2001; Wilkinson et al., 2000). In general, there is a lack of data and understanding of the complex mechanisms of neurotoxicity by these chemicals.

ATSDR estimated the direction of interaction for neurotoxicity to be additive for lead on methylmercury and methylmercury on lead (Agency for Toxic Substances and Disease Registry, 2006) and greater-than-additive interactions for methylmercury on PCBs and PCBs on methylmercury (Agency for Toxic Substances and Disease Registry, 2004). To date, interactions of lead on PCBs and PCBs on lead have not been evaluated by ATSDR.

***In Vivo* and *In Vitro* Studies**. The following section begins with the scientific literature that served as the basis for these ATSDR prognostications. In general, these studies have focused either on the mechanisms of neurotoxicity or the clinical and/or subclinical manifestations of adverse development related to maternal exposures: death, malformation, growth retardation and/or functional defect (Wilson, 1959, 1973; Wilson & Fraser, 1977). These studies are summarized below.

Lead and Methylmercury. ATSDR (2006) characterized the direction of interaction for neurotoxicity of lead on methylmercury and methylmercury on lead as additive with moderate to moderately low uncertainty. No BINWOE score was provided (Agency for Toxic Substances and Disease Registry, 2006). This risk characterization (=III.C.) was based upon the evidence of two animal studies (Bellés, Albina, Sánchez, Corbella, & Domingo, 2002; Congiu et al., 1979).

Bellés, Albina, Sánchez, Corbella and Domingo (2002) exposed pregnant mice on gestation day 10 to lead nitrate (25 mg/kg) subcutaneously then, five minutes later, administered methylmercury chloride (12.5 mg/kg) by gavage. These mice were sacrificed on gestation day 18. Three fetuses from each dam were autopsied. Data were evaluated using one-way ANOVA, χ^2 analyses and independent sample *t*-tests. Binary chemical exposure was associated with a statistically significant increase ($p < 0.05$) in maternal deaths and a significant decrease in the number of litters than either chemical alone, indicating a synergistic effect for maternal toxicity. By comparison, no statistically significant differences were found in fetal deaths or physical anomalies. As a result, these researchers concluded lead and methylmercury to be additive for fetal toxicity at the doses tested.

In the study by Congiu et al. (1979), male rats were injected with lead nitrate (20.7 mg/kg), then given methylmercury chloride (0, 34.6, 39.6 or 44.6 mg/kg) by gavage 24 hours later. An equal number of rats were sacrificed prior to gavage and at 6 and 24 hours following gavage. Data were evaluated using ANOVA and Fisher's *t*-test. Pretreatment with lead nitrate potentiated methylmercury chloride in a dose-related response resulting in a higher mortality rate than among those given methylmercury chloride alone. Dose-dependent differences could account for these varying results (Meacham et al., 2005).

Since these studies were published, four *in vitro* and *in vivo* mechanistic studies on the neurotoxic interaction between methylmercury and lead were published in English from January, 2000 to December, 2009.

In the study by Chetty, Rajanna, Hall, Yallapragada and Rajanna (1996), rats received lead acetate (25 mg/kg) or methylmercury chloride (5 mg/kg) by intraperitoneal infusion for 3 or 24 hours. Another group of rats received lead acetate (25 mg/kg/day) or methylmercury chloride (2.5 mg/kg/day) for seven days. These researchers found lead and methylmercury each enhanced the binding affinity of two receptors to cerebellar intracellular membranes in a concentration-dependent manner when compared to controls ($p < 0.05$). Each chemical had a slightly different effect on each receptor. It is believed that these two receptors are integral to intracellular calcium regulation which in turn, influences neuronal activity.

In their 1997 *in vitro* study, Rajanna, Rajanna, Hall and Yallapragada examined the effect of methylmercury chloride or lead acetate on the binding affinity of a different receptor (NMDA) in neonatal (ten days old) and adult rat cerebral cortices. These researchers found significant dose-dependent inhibition of this binding affinity. These effects were more pronounced in the neonatal brain than in the adult brain.

The remaining two studies used *in vitro* toxicity assays to predict cellular level effects and identify toxic mechanisms of these chemicals on neural cells and cloned neural cells (Suñol, 2010).

Radio, Freudenrich, Robinette, Crofton and Mundy (2010) cultured cerebellar granule cells with astrocytes prepared from six-to-eight day-old rats. Separately, a PC12 cell clone, Neuroscreen-1™ was treated with nerve growth factor. Both cell cultures were optimized over eight days to ensure neurite outgrowth and cell viability. Then, each cell culture was exposed once to methylmercury chloride or lead chloride in concentrations from 1 µM - 100 mM. Total neurite length and cell viability were

examined 96 hours after exposure. Data were analyzed using two-way ANOVA, Student-Newman-Keuls' and Dunnett's tests. Lead and methylmercury each inhibited neurite outgrowth significantly ($p < 0.05$) in both culture types. Unlike lead chloride, methylmercury chloride affected neurite length at concentrations less than those that affected cell viability. Each chemical demonstrated preference for different cell types.

Hogberg, Kinsner-Ovaskainen, Coecke, Hartung and Bal-Price (2010) prepared primary cultures of neuronal and glial cells from 7-day-old rat cerebellar granule cells. They incubated these cultures for 24 hours then exposed them to lead chloride or methylmercury chloride for up to 12 days. Cells were evaluated at 1, 4, 8 and 12 days for neurite outgrowth and the later stages of morphological maturation by measuring gene expression of messenger ribonucleic acid (mRNA) for specific neuronal and glial markers using spectrophotometry. After logarithmic transformation of data, statistical analyses included one- and two-way ANOVA. These researchers found neuronal markers were more sensitive to methylmercury chloride while lead chloride affected glial markers.

PCBs and Methylmercury. ATSDR (2004) characterized the neurotoxic interaction effect of PCBs on methylmercury and methylmercury on PCBs as greater-than-additive with a BINWOE score of +0.20 (Agency for Toxic Substances and Disease Registry, 2004, pp. 90-93). This risk characterization (II.C.b.) was based upon the evidence of impaired neurodevelopment determined by one *in vitro* study (Bemis & Seegal, 1999) with a moderate degree of uncertainty due to one negative *in vivo* study (Tanimura, Ema, & Kihara, 1980).

In the Bemis and Seegal study (1999), dopamine concentrations were significantly decreased ($p \leq 0.001$) in adult rat brain (striata) when exposed to PCBs (1:1 mixture of Aroclor™ 1254/1260) and methylmercury as compared to either chemical alone. Aroclor™ is a commercially available PCB mixture. These observed values were lower (20-50%) than predicted values, suggesting a synergistic effect. To control for unequal cell size, data were analyzed using one-way ANOVA (*F* statistic) so that the varying number of observations could be weighted. Interactions were analyzed using two-way ANOVA with Bonferroni-corrected post hoc *t*-tests. Results were reported as a percentage of the average control value in order to reduce variance among the 14 individual experiments. These researchers attributed this synergy to a common site of action involving intracellular calcium regulation in neural cells.

By comparison, Tanimura, Ema, and Kihara's (1980) study results were inconsistent. While mortality was higher than controls among offspring of female mice exposed throughout gestation and lactation to Kanechlor™ , another commercially available PCB mixture at 500 ppm and methylmercury chloride at 0, 0.4, or 4 mg/kg in a dose-related response, there were no statistically significant differences in neurodevelopment and neurobehavioral tests among binary exposed groups versus singularly exposed groups; an additive effect.

In addition to these studies, 14 *in vitro* and *in vivo* mechanistic studies specific to neurotoxicity were published in English from January, 2000 to December, 2009. These studies demonstrated interaction between PCBs and methylmercury after preconceptual, gestational and/or lactational exposure (Coccini et al., 2007; Fischer, Fredriksson, & Eriksson, 2008). However, the characterization of this interaction

varied widely from antagonistic (Bemis & Seegal, 2000; Sitarek & Gralewicz, 2009; Vettori et al., 2006) to non-additive (Coccini et al., 2006; Widholm, Villareal, Seegal, & Schantz, 2004) to additive (Castoldi et al., 2006; Costa, Fattori, Giordano, & Vitalone, 2007; Roegge et al., 2004) to synergistic (Bemis & Seegal, 2000; Cheng et al., 2009). Goldoni et al. (2008) found asynchronous exposure produced antagonism when methylmercury preceded PCB 153 and additivity when PCB 153 preceded methylmercury. Gender differences in genetic expression were found among perinatally-exposed adult rat progeny (Padhi et al., 2008). These varying results may be due to differences among the mechanisms studied, outcomes evaluated and variability in tissue-, time- and dose-dependent bioaccumulation (Meacham et al., 2005).

PCBs and Lead. ATSDR did not characterize the interaction of lead and PCBs. A literature search of titles and abstracts was conducted in PubMed using keywords (PCBs and Pb and interaction). This search revealed no *in vitro* and *in vivo* mechanistic studies specific to neurotoxicity for PCBs on lead or lead on PCBs published in English from January, 2000 to December, 2009.

Human Studies. To date, few human studies have examined exposures to combinations of these environmental chemicals among women of childbearing age. A literature search was conducted in PubMed using keywords (methylmercury and Pb and PCBs and women) for studies published in English from January, 2000 through January, 2010. Studies of maternal exposures with neonatal outcomes were excluded. Search parameters were extended until two studies emerged. They are reviewed here.

Qin et al. (2010) found significantly higher PCB ($p < 0.05$), mercury ($p < 0.01$) and lead ($p < 0.01$) levels in the subcutaneous adipose abdominal tissue of ethnic Chinese women living in Hong Kong who were diagnosed with non-cancerous tumors of the uterus (uterine leiomyomas) versus those women who did not have this diagnosis. Statistically significant differences ($p < 0.01$) were found between these two groups for lead and mercury in visceral fat. These adipose tissue samples were obtained during elective abdominal surgery (24 cases) and liposuction (20 controls) performed at six hospitals and six cosmetic surgery clinics in Hong Kong. Questionnaires were administered by trained interviewers regarding age, weight, height, number of seafood meals per week, health status and medical history. Gravidity and lactation histories were not elicited. Any woman with a history of UL was excluded from the control group. Analyses of samples were conducted using cold vapor atomic fluorescence spectrometry for total mercury and inductively coupled plasma-optical emission spectrometry for lead, and gas chromatography-mass spectrometry for PCBs. Researchers did not document where these samples were analyzed or what quality control procedures were executed. Data were analyzed using Student's *t*-test, Duncan's multiple range tests and Pearson's correlation. Correlations of xenobiotic levels between chemical pairs were not calculated. Xenobiotic levels were strongly correlated with increased seafood consumption, body mass index, and age. Limitations of this study included small sample size.

In the cross-sectional study conducted by Denham et al. (2005), tribal members collected blood samples from 138 Akwesasne (Mohawk) Nation girls aged 10 to 16.9 who resided within ten miles of the Mohawk Nation's border. Tribal members who

collected the data had no prior knowledge of exposure status at time of data collection. Attainment of menses was self-reported as present or absent at time of blood sampling. Demographic data were obtained from the girls' mothers by trained Akwesasne interviewers. Those with fetal alcohol syndrome or other serious physical or mental condition as diagnosed by a physician were excluded. Analyses of samples were conducted using cold vapor atomic fluorescence spectrometry for total mercury, Zeeman-corrected graphite furnace atomic absorption spectrometry for lead, and gas chromatography with electron capture detection for lipid-adjusted PCBs. Heavy metals were analyzed by a different laboratory than that used to analyze congener-specific PCBs. No details were provided regarding laboratory quality control procedures. Values were logarithmically transformed prior to statistical analysis. The median age at menarche was 12.2 years, comparable to the distribution found in NHANES III (1997-1998). Binary logistic regression analyses were performed on single toxicants and total toxicants. Age and lower socioeconomic status were strongest predictors of menses onset. Body mass index (BMI) did not affect the model. The odds of having reached menarche decreased with blood lead levels above the geometric mean; this relationship was nonlinear. Similar results were found with levels of four estrogenic PCB congeners (52, 70, 101/90, 187). While a nonlinear effect of mercury was observed, it was marginally significant ($p = 0.08$) at the 95th percentile. Lead and PCBs were found to have a statistically significant interaction ($p < 0.05$). Limitations of this study included small sample size which affected the researchers' ability to test interactions.

Chapter Summary

Existing definitions and measurements of exposure in five disciplines central to environmental health were explored. The definition and measurement of exposure was aligned with current principles and practices in environmental health nursing. Six exposure-related concepts (environment, agent, human, dose, health and vulnerability) were identified and defined. After a transdisciplinary review, the conceptual framework chosen for this dissertation was Sexton, Olden and Johnson's modified environmental health paradigm (1993a) because it so aptly described exposure and the intersection of an agent's toxicity with the target's vulnerability. The historical and political context of this framework's development, stated purpose and goals, focus, scope and basic assumptions were outlined. A brief review of published research studies and critical analyses that tested the framework's concepts and operational constructs were provided. To date, no known tests for validity and reliability have been performed on this model.

Selection of the three chemicals of interest (lead, methylmercury and PCBs) was based upon evidence of their pervasiveness, persistence and co-occurrence in the environment; the existence of scientific evidence demonstrating that exposure to any one of these chemicals has neurobehavioral and/or neurodevelopmental consequences in animal models and human population studies; and existence of scientific evidence that these chemicals bioaccumulate in such a way that past and current maternal exposures have the potential for transgenerational consequences.

Despite what is known about the hazards of exposure to these specific environmental chemicals, the health effects from exposures to multiple environmental

chemicals and their corresponding biologically-effective dose are relatively unknown. *In vivo* and *in vitro* mechanistic studies of binary combinations of these chemicals are limited and their findings contradictory. These contradictions may be due to differences among the mechanisms studied, outcomes evaluated and variability in tissue-, time- and dose-dependent bioaccumulation. A search of the scientific literature identified only two human studies that evaluated health outcomes of exposures to each of these three chemicals among childbearing-aged women.

Once the concepts were defined and theoretical framework chosen, the data source was searched for congruent measures of the independent variables. These measurements as well as their validity and reliability are described in the next chapter. Other details in Chapter Three include detailed information on NHANES, data processing, analytic procedures and research ethics.

CHAPTER 3

METHODOLOGY

This chapter begins with a reiteration of this study's aim and research questions. Then, the choice of research design is discussed followed by a description of the data source that includes a brief summary of the origin of NHANES. Three major concerns involving the use of these existing data are addressed. A description of the dataset and study population are provided. Measurements of all dependent and independent variables are described and their validity and reliability are reviewed. Data processing and analytic procedures are detailed. Aspects of research ethics are discussed with regard to NHANES and this study.

Aim

The aim of this research was to examine childbearing-aged and pregnant childbearing-aged women's exposures to specific environmental chemicals known to have neurobehavioral and neurodevelopmental consequences in animal models and human population studies. This dissertation focused on exposures to each of these chemicals individually and in four different combinations and permutations. Additionally, this dissertation identified those population subgroups at highest risk for two or more xenobiotic (chemical-specific) blood levels at or above the geometric mean. This research used existing data from the National Health and Nutrition Examination Survey (NHANES), a national probability sample.

Research Questions. This study had three research questions:

1. What was the prevalence of childbearing-aged and pregnant childbearing-aged women's exposures to each of the following environmental chemicals: lead, methylmercury and polychlorinated biphenyls (PCBs) as measured by chemical-specific (xenobiotic) levels at or above geometric mean in blood or serum of these women who were living in the United States from 1999 through 2004?

2. What combinations and permutations of chemical exposures were most common among these childbearing-aged and pregnant childbearing-aged women as evidenced by xenobiotic blood levels at or above the geometric mean?

3. What, if any, subsets of childbearing-aged women were disproportionately exposed to two or more of these environmental chemicals based on susceptibility-related attributes (reproductive status, age, health and nutritional status), exposure-related attributes related to acculturation, proximity (residential characteristics and occupation), activity (diet and tap water supply) and behavior (alcohol consumption and tobacco use); socioeconomic factors (education, employment, income and marital status) and race-ethnicity?

Choice of Research Design

As little is known about exposures to combinations of these environmental chemicals among childbearing-aged and pregnant childbearing-aged women, this research was a descriptive and exploratory study. A cross-sectional study design was the best study design for determining the prevalence of exposure(s) among this population as a whole and within subgroups. A cross-sectional study design reveals patterns and connections among exposures and specific characteristics of vulnerability

based on existing scientific literature (Kleinbaum, Kupper, & Morgenstern, 1982). Such findings allow for the generation of new hypotheses that can be subsequently evaluated using more robust study designs including longitudinal, prospective cohort and case-control studies. Because a cross-sectional study is non-directional that is, all data are collected at a single point in time, this study design is particularly useful in describing exposures which have inherent individual variability and uncertainty in measurement. However, a very large number of study participants are required for such a study to detect differences among population subgroups. A study design that employs random probability sampling for selecting its study participants provides representative estimates of exposures. Such estimates are useful in future public health planning. Although all these study design attributes are desirable, a cross-sectional study in which a large amount of original data are collected and encoded is prohibitively time-consuming and expensive. As a result, a more practical and economical approach is to conduct a secondary analysis of existing cross-sectional data.

Description of Data Source

This study's research questions were addressed through secondary analysis of existing data from the National Health and Nutrition Examination Survey (NHANES), 1999 through 2004. NHANES is a continuous population-based survey from the Centers for Disease Control and Prevention (CDC) National Center for Health Statistics (NCHS). Data are publicly available online. NHANES provides a probability sample of baseline information on the health and nutritional status of the non-military, non-institutionalized adults and children living in the United States. As

part of this survey, biomonitoring data were collected for more than 116 environmental chemicals or their metabolites including all the chemicals of interest to this study (Centers for Disease Control and Prevention, National Center for Environmental Health, 2007).

Origin of NHANES

The need for scientific measurement of the health and well-being of the people living in the United States was recognized decades before the National Health Survey Act became law in 1956 (Khrisanopulo, 1963). By 1956, data from a previous national study were obsolete and data from regional studies were limited in scope. There was a growing demand for uniform and valid national morbidity and healthcare-related statistics, particularly as they related to chronic disease. Projected applications for these statistics included administrative planning, workforce availability, potential consumer markets, health education, provision of health services and medical research (Storck, 1966; U.S. National Committee on Vital and Health Statistics, Public Health Services, Division of Public Health Methods, 1957). The purpose of the U.S. National Health Survey Act (1956) was

> to provide for a continuing survey and special studies to secure on a non-compulsory basis accurate and current statistical information on the amount, distribution, and effects of illness and disability in the United States and the services received for or because of such conditions and for studying methods and survey techniques for securing such statistical information with a view toward their continuing improvement.

Plans for a continuing national health survey were crafted by consensus committees comprised of stakeholders from federal, state and city governments, healthcare, academia and insurance. Most notable was the careful consideration of conceptual definitions. For example, health was "a continuous scale of well-being" and morbidity

was “a general word to be used to designate illness (manifest and non-manifest), injuries, and impairments” (Khrisanopulo, 1964, p. 4). There was an acknowledgment that analysis would be at the individual level even though the study population was the general population or some segment of it (Linder, 1958).

As a result of the National Health Survey Act, the National Center for Health Statistics (NCHS) was created. The first National Health Examination Survey (NHES I) was conducted in 1960. National attention on the link between dietary habits and disease led to the addition of continuing nutrition surveillance to the survey in 1971 (Editor, 1969). By 1977, there was an increased awareness of the influence of environment on health and the need to collect environmental health statistics for conducting epidemiological studies (U.S. National Committee on Vital and Health Statistics, 1977). As a result, NHANES was broadened to include measures of environmental exposures (Appendix E: History of NHANES).

Secondary Data Analysis

There were three major concerns involving the use of these existing data: selection and feasibility criteria; theoretical and conceptual congruency between the original and new research questions; and internal and external validity and reliability issues in selection and recruitment of original survey participants, survey content, and data collection, encoding and analysis. As a result, a thorough review of NHANES was conducted so that real and potential biases within the original research could be identified. This review provided some anticipatory guidance in selecting specific variables and implementing statistical controls prior to analysis.

Selection and Feasibility Criteria. NHANES was selected because this dataset best answered this study's research questions in that it contained a plethora of information on environmentally-related exposures of interest. The NHANES dataset was compatible with available hardware and software and the data have been subjected to vigorous control standards. NHANES provided supporting documentation specifically, codebooks, notations on recoding, and information regarding the data collection process so that the quality of the data was able to be assessed properly (Centers for Disease Control and Prevention, National Center for Health Statistics, n.d.b). These data were obtained in an ethical manner with regard to informed consent and confidentiality and there were provisions for continued protection of participant identity (Centers for Disease Control and Prevention, National Center for Health Statistics, 2010c). These data were publicly and freely available online at http://www.cdc.gov/nchs/nhanes.htm.

Theoretical and Conceptual Congruency. NHANES was theoretically congruent with this research study. It was a semi-quantitative survey that was structured, cross-sectional and non-experimental. Since this study was a quantitatively-based study, preference was given to laboratory-based and/or objective measurements whenever possible and appropriate. Informed by Sexton, Olden and Johnson's modified environmental health paradigm (1993a) and the literature review, NHANES was scrutinized to identify measures which best represented the concepts. Both the level of analysis and unit of analysis were compatible with this study.

Recognition of real and potential biases within the original research provided some anticipatory guidance when specific variables were selected and statistical

controls were implemented (Kneipp & Yarandi, 2002). This study remained congruent with the sampling parameters of the original dataset. For example, even though all female participants aged 12 to 59 and menstruating females as young as eight were tested for pregnancy status, NHANES tested women aged 16 to 49, inclusively for the three chemicals of interest (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009i). To remain congruent with the sampling parameters of the original dataset, female children ages 16 to 21 were included in this study and females younger than age 16 and older than 49 were excluded. This exclusion may have underestimated true pregnancy rates slightly.

Validity and Reliability.

Selection of Original Survey Participants. NHANES employed a four-stage, unequal probability and cluster sampling method to select study participants from the U.S. population. For each twelve-month period, NHANES selected twelve to fifteen counties (some contiguous) from across the United States and divided them into block segments using U.S. census data. Individual block segments were identified for sampling and subsequently, a cluster of households from each selected block segment was drawn at random. The probability-proportional-to-size (PPS) sampling technique for selecting counties and block segments ensured that the probability of selecting any one sampling unit was proportional to the U.S. population with the characteristic of interest such as geography and the proportion of minority populations (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009h). Subsequentally, NHANES randomly selected from within these screening sub-domains (age, sex, and race-ethnicity) one or more residents from each household to

be study participants using quota sampling with replacement (Centers for Disease Control and Prevention, National Center for Health Statistics, 2010b). Using quota sampling with replacement does not insure that those who chose not to participate in the survey were identical to those who chose to participate in the survey. However, in their examination of the 2000 NHANES survey, Wendler et al. (2006) compared consent rates among Non-Hispanic Whites, Non-Hispanic Blacks and Hispanics for the interview and medical examination portions of the survey. Odds ratios (*OR*) were calculated. Non-Hispanic Blacks were less likely than Non-Hispanic Whites to participate in the initial interview (*OR* = 0.97) while Hispanics were slightly more likely to participate (*OR* = 1.63). Only those individuals who consented to be interviewed were invited to participate in the medical examination portion of the survey. Non-Hispanic Blacks and Hispanics were more likely than Non-Hispanic Whites to participate in the medical examination with odds ratios 1.04 and 1.56, respectively. However, these last findings were not statistically significant.

In NHANES, there was a purposeful over-sampling of select subgroups: adolescents, the elderly, African-Americans, Mexican-Americans and low-income Non-Hispanic White-Americans. Oversampling increased the reliability and precision of health status indicator estimates for these subgroups (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009i). The tests administered for each individual were based on probability sampling. A sample weight was assigned to each person (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009i). Sample weights accounted for specific data purposely not collected that is, unequal probability of selection. NHANES based these sample

weights on U.S. census data for gender, age and race-ethnicity with references to five racial and ethnic categories, that is, Non-Hispanic White; Non-Hispanic Black; Mexican American; Other Hispanic; and Asian, Pacific Islander, Native American, or Multi-Racial (Centers for Disease Control and Prevention, National Center for Health Statistics, 2010e). Demographic analysis of the 2000 U.S. census estimated a net undercount (-0.1%) which resulted from a combination of duplicate enumeration and undocumented migration (Mulry, 2006). This sampling error underestimated overall prevalence slightly (Table 1).

Recruitment of Original Survey Participants. NHANES sent communiqués regarding the survey to the media as well as state, county and local governments. Area households received a letter of introduction. Interviewers canvassed a sample cluster and asked at each house a set of questions to determine if anyone in the house was eligible to be in the sample. Interviewers included those who were bilingual (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009i).

Original Survey Content. There were four components to the NHANES survey: demographics, data collected through household and mobile examination center interviews regarding alcohol consumption, tobacco use, medical, dietary and reproductive histories; physical examinations and laboratory tests (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009i). Survey content was determined through a rigorous evaluation process in which components were added, modified, supplemented or dropped across survey years (Centers for Disease Control and Prevention, National Center for Health Statistics, 2004). "It can be

changed depending upon the complexity, reliability and validity of the health measure. … It still takes about two years of data collection to have stable national estimates" (Berman, Ostchega, Reed-Gillette, & Porter, 2003, p.713).

Original Survey Data Collection, Coding and Analysis. NHANES instituted a comprehensive and integrated quality assurance and quality control program encompassing a wide range of activities that occurred prior, during and after data collection to ensure high quality data and reduce systematic error (Berman et al., 2003). Bilingual interviewers who administered the structured in-home interview used a pen-touch handheld computer. Interview data were generated from self-reports. Within a few weeks of the home interview, the physical examination and laboratory testing occurred at a Medical Examination Center (MEC) centrally located within the survey area. It took approximately 3.5 hours per person, depending upon age. Select population subgroups or a given percentage of study participants may have been included or excluded from specific MEC components and were so noted. All questions were administered by trained interviewers except those of a "sensitive" nature (e.g., illicit drug use and sexual behaviors). These questions were self-administered using audio computer-assisted technology to minimize response bias. All MECs had identical environment and equipment. To minimize interviewer bias, all field staff (physicians, medical and health technicians, dietary and health interviewers) received comprehensive and annual refresher training. The contract medical personnel conducted the examination and laboratory phases of the survey using standardized procedures. From within the MEC, digital measuring equipment automatically transmitted data to central databases. Physicians entered physical

examination data directly into a computer. Interviewers used a pen-touch handheld computer to conduct additional interviewer-administered questionnaires. These measures decreased the occurrence of transcription or coding errors. Prior to release, data were checked for inconsistencies and "scrubbed" by identifying, replacing, modifying or deleting these errors. "Don't Know" and "Refused" answers were each coded differently. Incomplete data or incomplete survey components were coded as missing. Off-site contract laboratories analyzed some of the biological and environmental specimens. All laboratory specimen-related transport, storage and analytical procedures were standardized to maximize reliability and validity. As part of the overall quality assurance process, all collection materials and storage containers used for trace element assays were initially prescreened for environmental contaminants to minimize external contamination. External contaminants can limit accuracy especially at levels approximating detection limits. Analytical methods were selected in accordance with validated standards by the Clinical Laboratory Standards Institute and have been described elsewhere (Centers for Disease Control and Prevention, National Center for Health Statistics, n.d.b, 2009a, 2009b, 2010a).

In conclusion, NHANES contained good quality and useful data which were valid and reliable. It was theoretically and conceptually congruent with this study. Details regarding specific measures of validity and reliability for each dependent and independent variable are provided in the sections that follow.

Dataset Description

The dataset for this study was the NHANES population-based survey that collected data on the health and nutritional status of adults and children in the U.S.

from 1999 to 2004. NHANES was a semi-quantitative survey that was structured, cross-sectional and non-experimental. It was a nationally representative sample even though the study excluded non-civilian and institutionalized people. There was a purposeful over-sampling of select subgroups: adolescents, elderly, Non-Hispanic Blacks, Mexican-Americans and low-income Non-Hispanic Whites to increase the reliability and precision of health status indicator estimates for these groups. To overcome these selection biases, all data were weighted, thus allowing population estimates to be calculated. NHANES data provided a basis for estimating subpopulations at-risk, for monitoring trends in prevalence (particularly risk-related behaviors and environmental exposures) and for establishing and maintaining a national probability sample of baseline information on the U.S. population (Centers for Disease Control and Prevention, National Center for Health Statistics, n.d.b).

Study Population

The subjects of this study were childbearing-aged women (16 to 49 years, inclusively) of diverse races and ethnicities who were living in the United States from 1999 through 2004. Males were excluded because this study was interested in female and maternal exposures only. Additionally, not all males were tested for all chemicals of interest. From 1999 to 2004, there were 11,865 childbearing-aged female participants interviewed (Table 2) of whom 95.6% were examined (Table 3) and one-third were tested in accordance with survey design (Table 4). From this one-third cohort, approximately 15% were dropped from the original survey subsample for the purposes of this study (Table 5 and 6) because they did not meet this study's criteria that is, female, age between 16 and 49 inclusively, interviewed, examined, tested for

all chemicals of interest and deemed to have reliable dietary recall. The final cohort for this study consisted of 3,173 women (Table 7).

While there were a total of 1,304 females whose urine tested positive for pregnancy, not all these females were of childbearing-age. Pregnant women of childbearing-age were identified as a subset; 11.5% of those examined were pregnant (Table 8) and 34.25% of those women were tested (Table 9). Approximately 13% of the pregnant childbearing-aged women were dropped from the subsample because they did not meet this study's criteria (Tables 10 and 11). The final cohort included a subset of 391 pregnant women (Table 12). The sample size was adequate for this study's purposes.

To obtain weighted estimates for 1999 to 2004, a six-year weight variable was created by assigning two-thirds of the four-year weight provided by NHANES for 1999 to 2002 if the person was sampled in 1999 to 2002 and assigning one-third of the two-year weight for 2003 to 2004 if the person was sampled in 2003 to 2004. This is possible because the 2003 to 2004 weights were comparable on a population basis to the combined 1999 to 2002 four-year weights (Centers for Disease Control and Prevention, National Center for Health Statistics, 2006). There were 52,827 observations read from the data set. Using weighted data allowed for estimation of true variance and generalizability to the U.S. population (Centers for Disease Control and Prevention, National Center for Health Statistics, 2010e).

Measurement of Dependent Variables

Biomarkers. For this study, the outcome of interest was based on evidence of biological uptake of two or more of the following chemicals: lead, methylmercury and

the summed value of four lipid-adjusted polychlorinated biphenyl congeners (118, 138/158, 153 and 180). Exposures were measured by the presence of these xenobiotics in the blood or serum of these women. A biomarker of exposure reflects the relationship between external contaminant (i.e., amount available for contact from all potential sources) and body burden (i.e., internal dose). The presence of a xenobiotic does not by itself cause disease or suggest a causal pathway. Equal xenobiotic values across chemicals do not infer relative equality in toxicity (National Research Council, 2006). Since this study examined exposures and not outcomes of said exposures, toxic equivalency across chemicals was not considered. The large sample size compensated for intra-individual exposure variability associated with intermittent exposures (Needham et al., 2005c; Phillips et al., 1989). Differences in participation by season, time of day for data collection, fasting time or usual/unusual food consumption were not correlated (p = 0.18 to 0.63) with exposure (Table 13).

Biomarkers have been used in population studies to establish prevalence rates and reference ranges, track exposure trends over time and identify subpopulations that may be at-risk for health effects related to chemical exposure (Schmidt, 2006b). For those who are most vulnerable (fetuses, infants and children, pregnant women, elderly, and those who were otherwise ill), a safe level may be zero if the health effects of an exposure may not yet be fully known or realized.

Lead. For 1999 through 2002, NHANES measured blood lead by electrothermal atomic absorption spectrometry (ET-AAS) with Zeeman background correction (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009b, 2010a). For 2003 to 2004, blood lead concentrations were determined by

inductively-coupled plasma dynamic reaction cell mass spectrometry (ICP/DRC-MS) (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009i). Both methods have been validated (Dos Santos, Rodrigues, Silva, Nascimento, 2006; Miller, Paschal, Gunter, Stroud, & D'Angelo, 1987; Parsons & Slavin, 1993; Zhang, Shimbo, Ochi, Eguchi, Watanabe, Moon, & Ikeda, 1997). While changing analytic methods has the potential to introduce an instrumental bias, the results from analyses of whole blood reference materials showed a statistically significant correlation between these two methods (Zhang et al., 1997).

Methylmercury. Total blood mercury is comprised of organic and inorganic species (Cernichiari et al., 1995). Unlike methylmercury, ethyl-, phenyl- and methoxyethyl- mercury are convert rapidly to inorganic mercury (Clarkson & Magos, 2006). Prior research has assumed methylmercury and organic mercury levels in blood to be synonymous (Björnberg et al., 2003; Mahaffey, Clickner, & Jeffries, 2009). This study concurred with this assumption. As a result, true methylmercury values may be overestimated slightly.

For 1999 through 2002, NHANES measured total blood mercury by flow injection mass spectrometry cold vapor atomic absorption with online microwave digestion. Inorganic mercury was measured using stannous chloride as a reductant without utilizing the microwave digestion process (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009b, 2010a). For 2003 to 2004, whole blood mercury concentrations were determined by inductively-coupled dynamic reaction cell plasma mass spectrometry (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009j). The results from analyses of whole

blood reference materials showed a statistically significant correlation between these two methods (Chan et al., 2009). These methods have been validated (Chan et al., 2009; Chen, Paschal, Miller, & Morrow, 1998; Tiezheng & Baasner, 1993).

Polychlorinated Biphenyls. PCBs are comprised of 209 congeners (Appendix F: Polychlorinated Biphenyl Terminology). Most PCB congener concentrations are highly correlated with each other and with total PCBs (Gladen, Doucet, & Hansen, 2003). Four congeners were selected (118, 138/158, 153, 180) for this study because they are most consistently detected in biological samples among the general population and measured most reliably (Frame, 2001). "In most epidemiological studies, these selected congeners are adequate for estimating total PCB exposure …" (Schantz, Wildholm & Rice, 2003, p. 374). It has been found frequently that three ortho-substituted non-coplanar congeners (PCBs 138/158, 153 and 180) account for 50% on average of total reported PCB congeners (Hansen, 1998) with PCB 153 approximately 25% of total reported PCBs (Koopmans-Esseboom et al., 1994). If present in appreciable concentrations, congener 118 has been included (Korrick et al., 2000; Schantz, Widholm, & Rice, 2003) to provide an improved estimate of total PCBs (M. Longnecker, personal communication, February 4, 2010). PCB153 has been proposed as the sole indicator of total PCB exposure to facilitate comparison with literature data among studies (Hagmar et al., 1998). To approximate total PCB levels, one could multiply PCB 153 levels by four (1/0.25 = 4) (M. Longnecker, personal communication, February 4, 2010). Since NHANES did not provide total PCB levels, the uncertainty associated with using just PCB 153 may be as high as 50% (Longnecker, 2001). As a result, this study did not use PCB153 as a (sole) proxy

measure of total PCB exposure. Grandjean et al., (2001) multiplied the sum of PCB congeners 138/158, 153 and 180 by two (1.0/0.5 = 2). Their study is the only study to have approached estimation of total PCB exposures in this manner. This study has defined PCB exposure as the sum of four congeners (118, 138/158, 153, 180) in accordance with Needham et al. (2005). As a result, true total PCB exposure may be underestimated somewhat.

NHANES measured individual PCB congeners by high-resolution gas chromatography/isotope-dilution high-resolution mass spectrometry using a solid phase extraction electron capture detection method. This method has been validated (Barr et al., 2003; Bernert, Turner, Patterson, & Needham, 2007; DiPietro et al., 1997; Patterson et al., 1994; Van den Berg et al., 1998). NHANES calculated the method detection limit for each analyte by correcting for sample weight and recovery, with recovery of the internal quantitation standard greater than 90% (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009j).

Known co-elutents include PCB 158, PCB 160, PCB 163, and PCB 164 for PCB 138; PCB 132 for PCB 153 (Centers for Disease Control and Prevention, National Center for Health Statistics, 2010a) and PCB 123 for PCB 118 (Van den Berg et al., 1995). These co-elutents are rarely found in human samples. As a result, potential interference from these co-elutents in the measurement of these specific PCB congeners was estimated to be minimal (Centers for Disease Control and Prevention, National Center for Health Statistics, 2010a).

Serum PCB levels correlate with serum lipid levels (Longnecker, 2001; Longnecker et al., 2003). As a result, each serum PCB was lipid-adjusted

(Schisterman, Whitcomb, Buck Louis, & Louis, 2005). In this study, lipid-adjusted PCB values were reported as whole-weight nanograms per gram lipid (ng/g lipid).

Limits of Detection. All specimens with a level at or above the upper limit of detection were diluted prior to reanalysis and recalculation (Centers for Disease Control and Prevention, National Center for Health Statistics, 2010a). As a result, readings above the upper limit of detection did not require any further adjustment (Taylor, 1987).

The lower limits of detection were 0.3 μg/dl for lead (1999-2004); 0.137 μg/dl (1999-2004), 0.1 μg/dl (2001-2002) and 0.14 μg/dl (2003-2004) for total mercury; and 0.446 μg/dl (1999-2000), 0.396 μg/dl (2001-2002) and 0.446 μg/dl (2003-2004) for inorganic mercury. Lower limits of detection for PCB congeners varied as each sample had its own limit. The larger an individual sample volume, the lower the detection limit. NHANES documented all PCB values below the limit of detection.

Imputation of Values. Based on the variance for the analysis of samples, the analytical lower limit of detection is defined as the lowest level at which a measurement had a 95% probability of being greater than zero (Taylor, 1987). NHANES' lower limits of detection were defined as three times the standard deviation of ten repeat measurements of a sample's lowest concentration or that measurement determined to be statistically different from a sample blank, depending upon the analytical methodology (Centers for Disease Control and Prevention, National Center for Health Statistics, n.d.a). Methodological uncertainty is high closest to these limits of detection (Taylor, 1987). This definition is associated with a one percent risk of reporting false negatives/type II error – how much analyte might be present but not

detectable (Greizerstein, Gigliotti, Vena, Freudenheim, & Kostyniak, 1997). To ignore non-detectables would overestimate the mean. To set non-detectables to zero would underestimate it. While there are a number of methods available to provide a more accurate estimation of the mean and standard deviation, each has limitations. Hald's method (1952) cannot be used when the limit of detection (i.e., point of truncation) is not a known constant or when more than 50% data are non-detectable. Additionally, this method has been deemed too cumbersome and complex to be practical (Hornung & Reed, 1990). The Nehls and Ackland method (1973) assigns all non-detectables to one-half the lower limit of detection (LoD/2) with the assumptions that the true concentration lies between zero and one. The data below the detection limit follow a uniform distribution in the shape of a rectangle. "But when the proportion of non-detectables is such that the limit of detection is not greater than the mode, the general shape of the left side of a lognormal distribution is better approximated by a right triangle" (Hornung & Reed 1990, p. 48). Their method divides the lower limit of detection by the square root of two (LoD/$\sqrt{2}$). The bias of estimating the geometric mean in this manner has been estimated to be 0.05% (Table 14).

For this study, lead, total mercury and inorganic mercury met the criteria for using the Hornung and Reed (1990) method to address sample values less than the lower detection limit. Each lower limit of detection was less than the mode and each geometric standard deviation was less than 3.0 (Table 15). Based on the percentage of non-detectables that is less than 10% for lead and total mercury, and greater than 60% for inorganic mercury, the Hornung and Reed method overestimated the true

geometric mean 0.12% - 2.9% for lead and total mercury, and underestimated it more than 6.1% for inorganic mercury (Table 14).

NHANES used the Hornung and Reed (1990) method (LoD/√2) to impute values less than the lower detection limit after correcting for sample weight and analyte recovery (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009b, 2009j, 2010a). The Centers for Disease Control and Prevention, National Center for Environmental Health (2009) found these imputations made little difference in geometric mean estimates. This study's analyses of the data as described above concurred with this finding. As a result, this study made no additional adjustments for values less than the lower limit of detection.

Derivation of Methylmercury Values. Due to limits of existing analytic methodology, methylmercury could not be measured directly. As a result, each methylmercury (MeHg) level was derived by subtracting inorganic mercury (IHg) from total mercury (THg) (Cernichiari et al., 1995). Using this calculation, a negative value for methylmercury was observed in 18.4% cases among all NHANES participants and 15.1% cases among childbearing-aged female participants (Table 16). Mahaffey, Clickner and Bodurow (2004, p. 565). They attributed these negative values to differences in detection limits and recoded all methylmercury values less than zero equal to one-half inorganic mercury's detection limit. It was decided that this Mahaffey et al. method would be used in this study. This imputation may have underestimated total mercury and methymercury levels only slightly.

Logarithmic Transformation of Xenobiotic Values. Prior to data analysis, xenobiotic levels were transformed logarithmically to approximate normal

distribution. A geometric mean provides a better estimate of central tendency for these data which are distributed with a long tail at the upper end, a phenomenon found commonly among environmental chemical biomarkers (Centers for Disease Control and Prevention, National Center for Environmental Health, 2009). For this reason, logarithmic transformation is routinely performed in environmental health studies (Bellinger et al., 1991; Grandjean et al., 1992b; Park et al., 2007 and others). The geometric mean dampens the effect of higher values which would bias an arithmetic mean. The geometric mean represents a 50/50 distribution. Since values at +3 SD are of greatest concern to public health, all values were included in the analyses. Histograms of logarithmically-transformed detectable values demonstrated a normal (Gaussian) distribution (Figures 3 through 23). Since methylmercury was derived, values equal to zero presented a challenge to log transformation. As a result, a value of one was added to all methylmercury values prior to log transformation. Frequency distributions for lead, methylmercury and sum of PCBs prior to logarithmic transformation (Figures 24 through 26) were asymmetric (positively skewed). After logarithmic transformation, they approximated normal distributions (Figures 27 through 29).

Measurement of Independent Variables

Vulnerability was measured by susceptibility-related attributes, exposure-related attributes, socioeconomic factors and race-ethnicity (Table 17).

Susceptibility-Related Attributes.

Reproductive Status.

Pregnancy. A urine test for pregnancy was performed on all female participants aged 12 to 59 years and menstruating females aged 8 to 11 years. From 1999 to 2000, these data were released for females aged 18 to 59 only. As a result, the total number of pregnancies for these two survey years is underestimated for 16 and 17 year-olds. If a female did not report having regular periods in past 12 months, NHANES asked if she thought she was pregnant and, if yes, asked her the month of pregnancy (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009c). For this study, these self-reports of pregnancy were compared to their respective pregnancy tests. All positive pregnancy tests were coded as pregnant and all negative pregnancy tests were coded as not pregnant. If the pregnancy test was missing and the trimester of pregnancy was reported as second or third, the response was recoded as pregnant. If the pregnancy test was missing and the trimester of pregnancy was reported as first, it was coded as missing as the pregnancy could not be confirmed.

Parity and Gravidity. Female participants were asked if they were ever pregnant: miscarriages, stillbirths, tubal pregnancies, abortions and live births. Initially for this study, all respondents who were currently pregnant were included in "ever pregnant." Since gravidity is subject to recall bias (Hassan, 2006), "ever pregnant" was deleted in

the final analysis in favor of keeping "ever" versus "never" live birth. A separate variable for current pregnancy was created.

Lactation. If females did not report having regular periods in past 12 months, NHANES asked if they were breastfeeding. Additionally, survey participants were asked if they ever breastfed any of their children for at least one month (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009c). Currently, there is no consensus regarding the operational definition for breastfeeding (Thulier, 2010). For this study, "ever breastfed" was comprised of females 16 to 49 who breastfed one or more children for at least one month and those currently breastfeeding. Those who breastfed for less than one month were included in "never breastfed." This could have introduced a misclassification bias.

Age. Since NHANES oversampled 16 to 19 year-olds and restricted access to information about their alcohol consumption and tobacco use, females aged 16 years to 19 years (192 to 239 months) were considered one cohort while the other females were grouped by decade: 20 years to 29 years (240 months to 359 months), 30 years to 39 years (360 months to 479 months) and 40 years to 49 years (480 months to 599 months). Age in months was reported at time of examination.

Health Status. There are perceptual, biomedical, functional and adaptive aspects to health assessments (Sadana, Mathers, Lopez, Murray, & Iburg, 2001). For this study, health status was measured by perceived health status, the presence of co-morbidities, serum indicators of iron deficiency, and healthcare access and use.

Perceived Health Status. Self-rated health has been used globally to measure health perception (Gold, Franks, & Erickson, 1996). It has been shown to be a strong

predictor of mortality risk (McGee, Liao, Cao, & Cooper, 1999; Sadana, Mathers, Lopez, Murray, & Iburg, 2001). NHANES participants were asked "Would you say your health in general is (excellent, very good, good, fair or poor)?" Self-reported health perception is subject to responder bias (Reindl-Benjamins, Hummer, Eberstein, & Nam, 2004). Ethnic differences in response to this question have been demonstrated when the above five-point scale is used (Dunn, 2002; Kandula, Lauderdale, & Baker, 2007; Lee, 2000; Robine, Jagger, & Egidi, 2000). Therefore, to minimize this responder bias, a dichotomous response (excellent-very good-good or fair-poor) was used in this study.

Co-Morbidities. The Charleson Co-Morbidity Index (Charlson, Pompei, Ales, & MacKenzie, 1987) has been used widely in longitudinal clinical trials to predict 12-month life expectancy of an individual based on the relative risk of death for each disease. This index has demonstrated predictive validity for survival and treatment-related complications (Abdullah & Al-Salamah, 2009; Charlson et al., 2008; Charlson, Pompei, Ales, & MacKenzie, 1987; de Groot, Beckerman, Lankhorst, & Bouter, 2003; Wang et al., 2009). It is a weighted index on a continuous scale that accounts for the total number and relative seriousness of 19 medical conditions with an adjustment for each decade in age over 49 (Hall, Ramachndran, Narayan, Jani, & Vijayakumar, 2004). The Charlson Co-Morbidity Index provided a general description of each disease condition, developed from clinical definitions in Deyo, Cherkin and Ciol's (1992) adaptation for International Classification of Diseases diagnosis and procedure codes (Charlson et al., 2008).

All NHANES participants were asked to self-report on a broad range of diagnosed medical conditions: “Has a doctor or other health professional ever told you that you have (medical condition)?” “Do you still have (medical condition)?” and “During the past (specified time period), have you been on treatment for (medical condition)?” These general questions were linked with more disease-specific questions (Table 18). The specificity (99%) and sensitivity (78 to 90%) of self-reported disease prevalence has been validated (Oksanen et al., 2010). Disease burden may have been underestimated slightly in this study because these questions addressed only diagnosed - not undiagnosed - medical conditions.

NHANES did not address all medical conditions included in the Charlson Co-Morbidity Index. Specifically, NHANES excluded connective tissue diseases, hemiplegia, paraplegia, peripheral vascular disease and dementia. Questions relating to ulcer disease were asked of 1999 to 2000 participants only so 2001 to 2004 participants were coded as negative responses and which may have introduced a misclassification bias.

The Charlson Co-Morbidity Index defined tumor as “a solid tumor without documented metastases but initially treated in the prior five years” (Charlson et al., 1987, p. 383); this was differentiated from metastatic cancers. For this study, metastatic cancer was defined as reporting two or more cancers that were different from the primary site and more systemic in nature (e.g., nervous system or lungs). NHANES excluded individuals if they received chemotherapy within four weeks of the survey. This exclusion may have underestimated cancer and metastatic cancer rates somewhat.

The kidney questionnaire was asked only of participants 20 and older. The Charlson Co-Morbidity Index defined moderate renal insufficiency as serum creatinine greater than 3 mg/dl (Charlson et al, 1987, p. 382). Therefore, this laboratory cut-off value was used to identify or confirm moderate-severe renal disease in the absence of questions regarding diagnosis of kidney failure and use of kidney dialysis. Serum creatinine is determined by using the Jaffe Reaction method (Jaffe, 1886). This method has been validated (Chromý, Rozkosná, & Sedlák, 2008). Values less than 0.6 mg/dl were reported as less than 0.1 mg/dl. Values greater than 25 mg/dl were diluted prior to reanalysis (Centers for Disease Control and Prevention, National Center for Health Statistics, 2007a).

Acquired Immune Deficiency Syndrome (AIDS) has been defined as Human Immunodeficiency Virus (HIV) positive with a CD4 count less than or equal to 200 cells per cubic millimeter (Hanson, Chu, Farizo, & Ward, 1995; U.S. Department of Health and Human Services, n.d.). This laboratory-based definition was used to identify participants with AIDS-related complex in this study. Positive HIV status was confirmed if the enzyme immunoassay (EIA) was repeatedly positive and the Western Blot test was positive. If EIA was repeatedly negative, then the test for HIV was considered negative. If EIA was positive or indeterminate and the Western Blot test was indeterminate, then the HIV test was indeterminate. CD4 counts were performed for HIV-positive persons with available blood- and age-matched controls only. These tests are described elsewhere (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009j).

To distinguish mild liver disease from moderate or severe liver disease, serum albumin and total bilirubin levels were compared to those classifications established in accordance with the Child-Turcotte-Pugh Score (Child & Turcotte, 1964; Pugh, Murray-Lyon, Dawson, Pietroni, & Williams, 1973). Similar to the Charlson Co-Morbidity Index, the Child-Turcotte-Pugh Score was used originally to predict one- and two-year mortality outcomes among hospitalized individuals with chronic liver disease based on key laboratory values (serum albumin, total bilirubin, prothrombin time) and the presence or severity of ascites and/or hepatic encephalopathy. In this dissertation, liver disease was determined by serum albumin and total bilirubin only. Since NHANES excluded individuals with hemophilia as well as those who were institutionalized (hospitalized), it is unlikely that survey participants were individuals with abnormally high prothrombin times and/or clinically apparent severe liver disease (ascites and/or hepatic encephalopathy). These exclusions may have underestimated Child-Turcotte-Pugh scores minimally.

Serum albumin was determined by a bichromatic digital endpoint method and total bilirubin by a timed-endpoint diazo method using a Beckman Synchron© LX-20. According to the Centers for Disease Control and Prevention, National Center for Health Statistics (2009j), linearity data verified reportable ranges for albumin (1.0 - 7.0 μg/dl) and total bilirubin (0.1 - 30.0 mg/dl). As a result, nondetectables were not relevant and a formal limit of detection study was unnecessary.

While the Charlson Co-Morbidity Index (CCMI) was developed to assess an individual's burden of concurrent chronic disease, the CCMI is not all-inclusive and its predictive value is limited within a generally healthy population (Ware, Brook,

Davies, & Lohr, 1981). However, where the prevalence of co-morbidity is low, grouping disease conditions in this manner is statistically advantageous through increasing individual cell size.

*Iron Deficiency***.** Iron deficiency was operationalized by two or more of the following abnormal serum values: mean cell volume less than 81 fL, transferin saturation less than 15% and serum ferritin less than 12 µg/L after adjusting for age and sex (Looker, Dallman, Carroll, Gunter, & Johnson, 1997; Mei, Parvanta, Cogswell, Gunter, & Grummer-Strawn, 2003). These three biochemical indicators for iron deficiency are more sensitive and specific than either hemoglobin or erythrocyte protoporphyrin alone (Mei et al., 2003; Ross, 2002). Iron deficiency decreases red blood cell size resulting in lower mean cell volume. All serum iron is bound to transferin. Transferin saturation is calculated as a percentage by dividing serum iron by serum total iron binding capacity. Serum ferritin reflects iron stores (Bryant, Hopkins, Arceo, & Leitman, 2009). Iron deficiency among pregnant women is diagnosed using these same indicators (Blackburn, 2007; Burst, 2003; Gabbe, Niebyl, & Simpson, 2007). Therefore, these parametrics for iron deficiency were applied equally to pregnant and non-pregnant female participants in this study.

Mean cell volume was determined by a National Committee for Clinical Laboratory Standards' procedure (National Committee for Clinical Laboratory Standards, 1985). Serum iron and serum total iron binding capacity (TIBC) were determined by a modified automated 25-colorimetric method for 1999 to 2002 samples (Ramsey, 1957; Giovaniello, Bendetto, Palmer, & Peters, 1968) and by a timed-endpoint method for 2003 to 2004 samples. According to the Centers for

Disease Control and Prevention, National Center for Health Statistics (2009j), linearity data verified reportable ranges (serum iron: 5 to 500 μg/dl and TIBC: 0 to 500 μg/dl). As a result, nondetectables were not relevant and a formal limit of detection study was unnecessary.

For 1999 through 2003, serum ferritin was determined by a single incubation two-site immunoradiometric assay based on the general principles of assays as described by Addison et al., (1972) and Miles (1977) and modified by Jeong, Blackmore, and Lewin (1981). For 2004, serum ferritin was determined by immunoturbidimetry. Both methods have been validated (Lipschitz, Skikne, & Thompson, 1981; Dupuy, 2009).

Anemia appears only when iron deficiency is chronic and severe (Morón & Viteri, 2009). NHANES asked "During the past three months, have you been on treatment for anemia, sometimes called tired blood or low blood?" Affirmative answers to this question were noted. For this study, a new variable was created that combine iron deficiency and anemia treatment (Table 19).

Healthcare Access. The ability to recover and/or maintain health is closely tied to affordability and continuity of healthcare and social services (Lee, 2000). "Absent or inadequate healthcare deters preventive healthcare practices" (Sampselle, 2007, p. 222). Affordability of healthcare, continuity of healthcare and adequate healthcare are intertwined (Lu, Samuels, & Wilson, 2004). Health insurance is a major determinant of access to healthcare (Heck & Parker, 2002). Regular healthcare has been shown to be a key factor in promoting positive health outcomes (Gorman & Braverman, 2008). A regular source of healthcare has been associated with improved health (Shi &

Stevens, 2005). However, episodic care provided by a hospital emergency room or outpatient department is an inadequate source of healthcare (Mayberry, Mili, & Ofili, 2000). To assess an individual's access to healthcare, four questions were selected: "Do you have health insurance?" "If yes, what type?" "Is there a place that you usually go to when you are sick or need advice about your health?" "What kind of place do you go to most often?" (Centers for Disease Control and Prevention, National Center for Health Statistics, n.d.b).

***Nutritional Status*.** Three variables have been used extensively to assess nutritional status: food insecurity and body mass index (Morón & Viteri, 2009). Other validated measures include changes in dietary intake of fat, protein and micronutrients (Detsky et al., 1987; Kondrup, Rasmussen, Hamberg, Stanga, & Ad Hoc ESPEN Working Group, 2003).

Household Food Security. To assess household food security, NHANES used the U.S. Food Security and Hunger Survey Module (U.S. FSSM) a/k/a Core Food Security Measure (CFSM) (Bickel, Nord, Price, Hamilton, & Cook, 2000). This 18-item questionnaire asked about food security conditions experienced by adults and children within a given household over the prior 30 days and included questions regarding the use of food stamps as well as participation in the federal Special Supplemental Nutrition Program for Women, Infants and Children (WIC) programs in the prior 12 months. Administered at the state level, WIC is a federal program that provides supplemental food, healthcare referrals and nutrition education for low-income pregnant, breastfeeding and non-breastfeeding postpartum women, infants and children (up to age five) who are found to be at nutritional risk. Based on the total

score of affirmative answers, households were classified into one of four categories: fully food secure, marginally food secure, food insecure without hunger and food insecure with hunger. The concept of food insecurity with hunger was based on the definition of hunger as part of a continuum of food insecurity (National Research Council, 2005). Validity and reliability of this module has been confirmed across family structures and ethnic groups (Derrickson, Fisher, & Anderson, 2000; Gulliford, Nunes, & Rocke, 2006). NHANES assumed those households with more than five times the federal poverty threshold level were food secure, so they did not administer the U.S. FSSM/CFSM to these households. Households that were fully food secure were over-represented in the sample with valid data at the household, adult and child level (Centers for Disease Control and Prevention, National Center for Health Statistics, 2006). In this study, all fully food secure households were coded as such and included in prevalence estimates.

*Body Mass Index***.** Body Mass Index (BMI) is a heuristic measure of body weight based on the proportion of weight-to-height (kg/m^2). It is significantly correlated with total body fat content. Classifications include: underweight (less than 18.5 kg/m^2), normal (18.5 to 24.9 kg/m^2), overweight (25.0 to 29.9 kg/m^2), obese I (30.0 to 34.9 kg/m^2), obese II (35.0 to 39.9 kg/m^2) and extremely obese III (40.0 kg/m^2 or greater). These classifications have been validated. There is a significant increase in mortality risk where BMI is greater than or equal to 30 kg/m^2 (U.S. Department of Health, Education & Welfare, National Institutes of Health, National Heart, Lung and Blood Institute, 1998). As a result, this study dichotomized these BMI data at less than 30 kg/m^2 versus 30 kg/m^2 or more.

Dietary Intake of Select Nutrients. Study participants were randomly assigned to interview method (in-person or telephone) and time of day (morning, afternoon or evening). This study included only those who were interviewed face-to-face, completed the dietary survey and rated reliable by CDC trained, bilingual dietary interviewers. Dietary interviewers were required to have a B.S. degree in food and nutrition or home economics with at least ten credit hours in food and nutrition. All interviewers completed an intensive two-week training course followed by a week of supervised, practice interviewing. Minimum criteria for reliability included providing food descriptions more than 75% of the time, food amounts more than 85% of the time and knowing at least one food item per meal (Centers for Disease Control and Prevention, National Center for Health Statistics, 2003; Centers for Disease Control and Prevention, National Center for Health Statistics, 2007b). NHANES used a four-pass method (quick list, time-occasion-place, food details and final review) in which survey participants were given four opportunities to think through what they ate and drank over the prior 24 hours. This method has been deemed the most reliable dietary assessment method (Nelson et al., 2009). NHANES calculated these nutrient intakes from the 24-hr dietary recall using the University of Texas Food Intake Analysis System (FIAS©) in conjunction with the U.S. Department of Agriculture Survey Nutrient Database (Centers for Disease Control and Prevention, National Center for Health Statistics, 2003).

In this study, fat and protein 24-hr intakes were converted from grams to calories then divided by total calories consumed. This value was compared to its acceptable macronutrient distribution range (AMDR), adjusted for sex, age, pregnancy and

lactation (Institute of Medicine, 2005). This study dichotomized the ratio of fat intake to AMDR as recommended or less (0.00 to 0.35) versus more than recommended (greater than 0.35) and the ratio of protein intake to AMDR as less than recommended (0.00 to less than 0.10) versus recommended or more (0.10 or greater) (Table 20).

In this study, 24-hr intakes of iron, calcium and selenium were each divided by their respective recommended daily allowance (RDA) which had been adjusted for sex, age, pregnancy and lactation (Freedman, Guenther, Dodd, Krebs-Smith, & Midthune, 2010; Institute of Medicine, 2005). This study dichotomized these values as less than 1.0 versus 1.0 or greater. Because intakes did not include iron, calcium and selenium obtained from other sources such as dietary supplements, antacids, medications, plain drinking water, salt and seasonings added to foods at the table, true total intakes of these micronutrients may have been underestimated somewhat.

Exposure-Related Attributes.

Acculturation. Language spoken at home has been found to be the strongest predictor of acculturation. Residency as percent of lifetime and generational status have high internal consistency and strong correlation among existing acculturation scales (Alegria, 2009). Other proxy variables for acculturation have included country of birth, age at immigration or generation from immigration, length of time in (new) country, and (new) language proficiency (Alegria, 2009; Anderson et al., 1993; Carter-Pokras & Bethune, 2009; Felix-Ortiz, Newcomb, & Myers, 1994; Lee, Nguyen, & Tsui, 2009; Marin, Sabogal, Marin, Otero-Sabogal, & Paerez-Stable, 1987; Thomson & Hoffman-Goetz, 2009). All NHANES participants were asked their country of birth, the length of time in U.S, citizenship status and language spoken at home.

Those participants reporting their ethnicity as Mexican American or Other Hispanic were asked five additional questions pertaining to language use preferences, each with five answer choices: only Spanish, Spanish better than English, both equally, English better than Spanish, and only English. This eight-item acculturation questionnaire has demonstrated high internal reliability (Carter-Pokras & Bethune, 2009). It was used initially in the Hispanic Health and Nutrition Examination Survey (HHANES), a national probability sample conducted from 1982 to 1984 of 16,000 Mexican American, Puerto Rican and Cuban-Americans (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009f). For this study, birthplace was dichotomized as inside or outside the United States. The length of time in U.S. (less than five years versus five years or more) and language spoken at home (English versus non-English) were dichotomized as well. For Hispanic participants, answer choices for language spoken at home were recoded as English (only English, English more than Spanish, both equally) or non-English (only Spanish, Spanish more than English). Data were not coded in such a manner to allow residency as percent of lifetime or age at immigration to be calculated.

Dietary Consumption. Following the dietary 24-hr recall, a short questionnaire was administered whereby study participants estimated their fish and shellfish consumption during the past 30 days (Table 21) and intake of plain water during the previous 24-hr time period (Table 20).

Fish and Shellfish Consumption. Each study participant was asked, "Please look at this list of fish and shellfish." "During the past 30 days, did you eat any types of fish and/or shellfish listed on this card? Include any foods that had fish and/or

shellfish in them such as sandwiches, soups, or salads" (Centers for Disease Control and Prevention, National Center for Health Statistics, 2003).

Smith (1991) found that those experimental subjects who were provided with food group cues in the form of a list, reported significantly more food items than those with chronologically-based cues such as breakfast, lunch and dinner. As to the retention interval effect, omissions of food items were 50% after two weeks and 30% after four weeks and false recalls 30% after two weeks and 40% after four weeks when compared to food diaries (Smith, 1991). In a 24-hr dietary recall, Karvetti and Knuts (1985) found omissions of fish consumption were the lowest of all foods consumed (4%) with false recalls of fish consumption 7% when compared to observed food and nutrient intake. Additionally, these researchers found women to be somewhat more accurate than men. Generally, consistent food consumption patterns result in more frequent dietary recall. In the United States, approximately 9% of women consume fish at least once a week (Mahaffey et al., 2004).

Since this study did not examine exposure outcomes, actual amounts of fish and/or shellfish consumed were not considered. To minimize recall bias, separate variables for fish and shellfish consumption were each dichotomized as "ever" versus "never" eaten fish and/or shellfish in past 30 days. A composite variable for total seafood consumption was created as well.

Tap Water Consumption. Tap water was defined as plain and filtered tap water and water from a drinking fountain (Centers for Disease Control and Prevention, National Center for Health Statistics, 2003). Tap water potentially represents a fraction of total dietary water and moisture intake. NHANES asked study participants,

"In the prior 24-hr, how much of the plain water you drank was home tap water?" Tap water from residences represents a fraction of total tap water intake if an individual works, attends school, and/or eats outside the home (Shimokura, Savitz, & Symanski, 1998). It was decided to use 2,000 ml as the cut point for 24-hr tap water consumption as it represented 80% of RDA total water intake adjusted for gender and age (Institute of Medicine, 2005). Selection of this relatively high cutpoint may have underestimated exposures. Based on initial analyses of this study, use of residential water treatment systems may have overestimated exposures related to tap water intake as much as 11%.

Alcohol Consumption. Alcohol consumption was defined as a drink of one ounce (1 oz.) liquor such as whiskey or gin, twelve ounces (12 oz.) beer, and four ounces (4 oz.) wine, wine coolers or any other type of alcoholic beverage (Centers for Disease Control and Prevention, National Center for Health Statistics, 2003). Questions on alcohol consumption revolved around quantity and frequency within specified time intervals that is, lifetime, prior 12 months and prior 30 days. The general reliability, validity and utility of these measures have been supported (Del Boca & Darkes, 2003).

"Never" drinkers were defined as those who responded "no" to the question, "In your entire life, have you had at least twelve drinks of any type of alcoholic beverage?" Seldom drinkers were those who responded "yes" to this question but "no" to a second question, "In any one year, have you had at least twelve drinks of any type of alcoholic beverage?" Due to small cell size, "never" and "seldom" drinkers were grouped into one category in this study.

Women were categorized as drinkers if they responded "yes" to both of these questions and had at least one drink of alcohol on at least one day during the past 30 days. Those who responded "yes" to either of the following questions were considered "heavy" drinkers, "In the past 12 months, on how many days per week/month/year did you have five or more drinks of any alcoholic beverage?" and/or "Was there ever a time or times in your life when you drank five or more drinks of any kind of alcoholic beverage almost every day?" (Centers for Disease Control and Prevention, National Center for Health Statistics, 2003; Naimi et al., 2003).

For those women younger than 20, the alcohol consumption questionnaire was self-administered using audio computer-assisted technology to minimize response bias (Centers for Disease Control and Prevention, National Center for Health Statistics, 2003). Since these data were restricted, it was decided to code 16 to 19 year-old participants as "never or seldom" drinkers. This was in accordance with state laws that prohibit underage drinking. All laws were in effect prior to 1999. Although females tend to drink less often and less per occasion than their male counterparts (Zhong & Schwartz, 2010), this recoding may have underestimated true prevalence of alcohol consumption among these young women. Fryar, Merino, Hirsch, and Porter (2009) estimated as much as 18.5% females aged 16 to 17 are binge (heavy) drinkers.

Tobacco Use. Tobacco products included cigarettes, pipes, cigars, snuff, chaw and nicotine patches, gum or other nicotine products. Similar to alcohol consumption, questions on tobacco use revolved around quantity and frequency within specified time intervals that is, lifetime, per day and the prior 30 days.

For those women younger than 20, tobacco use questions were self-administered using audio computer-assisted technology to minimize expected response bias

(Centers for Disease Control and Prevention, National Center for Health Statistics, 2009i). Since these data were restricted from public access, it was decided to code participants aged 16 to 19 separately as "age-restricted."

"Never" tobacco users were defined as those study participants who responded "no" to a series of questions: "Have you smoked at least 100 cigarettes (20 pipes or 20 cigars or snuff 20 times or chaw 20 times) in your entire life?" (Bondy, Victor, & Diemert, 2009). "Former" tobacco users were those who responded "yes" to the preliminary questions but "no" to a second series of questions: "Do you now smoke cigarettes (pipes, cigars, snuff or chaw)?" Pack-years for former tobacco users could not be calculated from the data provided. While the literature supports the general utility of self-reported tobacco use, true prevalence may be underestimated by 6.2% as compared to serum cotinine levels, depending upon the population (Gorber, Schofield-Hurvitz, Hardt, Levasseur, & Tremblay, 2009).

Cotinine is a xenobiotic metabolite of nicotine. Serum cotinine reflects current use of tobacco products as well as environmental tobacco smoke exposure without differentiating exposure sources. Serum cotinine has a half-life of approximately 15 to 20 hours. Nicotine exposures prior to this time period are not captured by this biomarker. In general, current tobacco users tend to have blood cotinine levels 10 ng/ml or higher while "never" tobacco users exposed to no or very low levels of environmental tobacco smoke (ETS) typically have blood concentrations less than 1 ng/ml. Non-tobacco users with ETS exposures tend to have blood cotinine levels between these two values (U.S. Environmental Protection Agency, 2010b). Benowitz,

Bernert, Caraballo, Holiday, and Wang (2009) have recommended a cut point of 10 ng/ml.

NHANES analyzed serum for cotinine using isotope dilution-high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry (ID HPLC-APCI MS/MS) (Centers for Disease Control & Prevention, National Center for Health Statistics, 2009j). This analytical method has been validated (Bernert et al., 1997). Cotinine concentrations were derived from the ratio of native (98% laboratory grade cotinine) to labeled cotinine in the sample by comparisons to a standard curve. All specimens with a level at or above the upper limit of detection were diluted prior to reanalysis and recalculation. The lower limits of detection were 0.05 ng/ml for 1999 to 2001, and 0.15 ng/ml for 2002 to 2004. As explained previously, NHANES imputed values below these detection limits with values equal to the lower limit of detection divided by the square root of two (LoD/$\sqrt{2}$) that is, 0.035 ng/ml for 1999 to 2001 and 0.011 ng/ml for 2002 to 2004 (Centers for Disease Control and Prevention, National Center for Health Statistics, 2006). Using this method, the true geometric mean may be overestimated by 3.4 to 11.2% (Figures 30 to 32, Table 14). It should be noted that each lower limit of detection was equal to its mode and two geometric standard deviations were slightly larger than three (Table 22, Figures 33-34). If the Nehls and Ackland method (LoD/2) were used, the true geometric mean would have been underestimated by only 1.8% (Nehls & Ackland, 1973; Table 14).

In this study, self-reported tobacco use was correlated ($p < 0.0000$) to serum cotinine levels. However, information regarding those whose self-reported tobacco

use was age-restricted, 19.5% showed serum cotinine levels 10 ng/ml or higher. As a result, it was decided to use serum cotinine levels in lieu of self-reported tobacco use. Because there were questions about the validity of imputed values, it was decided that instead of using the geometric mean as a cut point for this variable, serum cotinine levels would be categorized as described above. Categorizing allowed for identification of tobacco users among females aged 16 to 19 as well as environmental tobacco smoke exposures among non-tobacco users. Important sources of nicotine exposure for non-tobacco users are the residence and the workplace. For current smokers, ETS may contribute as much as 23% of total nicotine exposure (Piccardo, Stella, & Valerio, 2010). NHANES asked study participants, "Does anyone who lives here smoke cigarettes, cigars, or pipes anywhere inside this home?" "At your current job or business, how many hours per day can you smell the smoke from other people's cigarettes, cigars, and/or pipes?" This study categorized ETS exposures as none, at home or at work, and both at home and at work; missing values were recoded as none. The exclusion of ETS exposures outside of home and work may have underestimated true exposure slightly.

Residential Characterisitcs. Variables pertaining to the built environment included specific housing conditions (e.g., tap water sources, residential water treatment, age and type of residence) and social factors (e.g., resident status, years at current residence and household size for crowding or population density).

Tap Water Sources. For this study, tap water sources were dichotomized into public or municipal versus private or wells with public sources as the referent category. Specific residential tap water treatment systems were dichotomized as well.

These water treatment systems included: Brita® or other pitcher water filters, a ceramic or charcoal filter, water softener, an aerator or reverse osmosis system. However, not all of these water treatment systems filter lead, methylmercury and PCBs. This may have represented a misclassification bias and underestimated exposure. For this variable, the referent category was no residential water treatment.

Age of Residence. In the absence of specific exposure data, residential age was used as a surrogate measure (Jacobs, Wilson, Dixon, Smith, & Evens, 2009; World Health Organization, European Centre for Environment and Health, 2006). In a study of children residing in Jefferson County, Kentucky, Kim, Staley, Curtis and Buchanan (2002) categorized residential age by decade of original construction. NHANES did not categorize age of residence in this manner (prior to 1940, 1940 to 1949, 1950 to 1959, 1960 to 1977, 1978 to 1989 and 1990 and newer). As a result, 1960 and 1978 were used as cut points in two separate variables. These cut points concurred most closely with promulgation of pertinent environmental regulations (Banned Hazardous Products, 1978; Banned Hazardous Substances, 1972, U.S. Environmental Protection Agency, 2009d, 2010a). There are limitations to using these dates. This researcher acknowledges the existence of a time lag between regulatory enactment and actual changes in the field. Additionally, these bans applied only to new housing construction and replacement of existing materials only when repairs or upgrades were made. Mitigation of existing structures is spurious but ongoing.

Type of Residence. For this study, attached and detached houses were grouped together. Since mobile or manufactured homes and trailers are located in distinctly different neighborhoods, they were grouped separately. All other types of residences

comprised the third category which included any missing data. Since NHANES identified individual block segments for sampling and subsequently drew at random a cluster of households from each selected block segment, it is unlikely that those who were homeless were included in the survey.

Resident Status. NHANES asked survey participants, "Is this residence owned, being bought, rented or occupied by some other arrangement by you or someone else in your family?" (Centers for Disease Control and Prevention, National Center for Health Statistics, n.d.b). This variable was categorized as owned (or being bought), rented, and other which included missing or unknown.

Years at Current Residence. Residency was dichotomized at five years in accordance with Dunn's study of self-rated health, mental health and household attributes (Dunn, 2002).

Household Size. The U.S. Census Bureau (2000) calculated household size by dividing the number of persons in households by the number of households. Dunn (2002) operationalized household size by the number of people per number of bedrooms while Pollack, von dem Knesebeck, and Siegrist (2004) relied on the total number of rooms. In this dissertation, it was not possible to create a similar composite variable due to small cell size. Instead, two separate variables were created. For the number of persons per household, there was a dichotomous variable with the cut point equal to the median (four). For the variable "total number of rooms in a residence" there were four categories: one to three, four to six, seven or more, and missing data.

Occupation. Once employment status was established, survey participants were asked about their current and longest-held jobs: "What kind of work were you doing last week?" "What kind of business or industry is this?" "Thinking of all the paid jobs

or businesses you ever had, what kind of work were you doing the longest?" "What kind of business or industry was that?" (Centers for Disease Control and Prevention, National Center for Health Statistics, 2008a). Trained coders grouped these industry and occupational data into 42 occupations and 45 industries using the 2000 U.S. Census Bureau Indexes of Industry and Occupations, North American Industrial Classification System or NAICS (U.S. Census Bureau, 2001a, 2001b, 2003a, 2003b). Due to small cell size, this study condensed these groups to two industry and two occupational categories (Tables 23 and 24). The decision to group sales positions with managerial and professional occupations and service positions with "heavy" industry-related occupations was based upon an assumed similarity in workplace chemical exposures. Data were not collected on those participants who held more than one job in different occupations or industries, thus introducing some opportunity for misclassification.

Total Hours Worked. The U.S. Department of Labor, Bureau of Labor Statistics (2008a) defined full-time work as 35 or more hours, so this value was used as the cut point for the variable "total hours worked in the prior week from all jobs and businesses." Time in current and longest employments was categorized as not working which included not applicable, less than five years, and five or more years. Although job duration may be somewhat age-related, the Bureau of Labor Statistics claims 65% of the baby-boomer generation experienced less than five years with the same employer with women spending 15% more time out of the workforce than men (U.S. Department of Labor, Bureau of Labor Statistics, 2008b).

Socioeconomic Factors. Socioeconomic factors included education, employment, income and marital status. While significant interrelationships exist among these variables, they are not redundant (Winkleby, Jatulis, Frank, & Fortmann, 1992).

***Education*.** Researchers have found that actual years of education do not reflect the potential socioeconomic effects of degree attainment. Not everyone who attends school graduates with a degree (Bauman & Graf, 2003; Frazis, Harrison-Ports, & Stewart, 1995; Kominski, & Siegel, 1995; Zajacova & Hummer, 2009). In NHANES, education was measured in years of schooling up to the twelfth year, then by degree attainment (i.e., high school diploma or equivalent, secondary and post-secondary degrees). Since the greatest disparities in health occur among those without a high school diploma or equivalent (Dube, Asman, Malarcher, & Carabollo, 2009; Kim, 2008; Lynch, 2003), this study chose attainment of high school diploma or equivalent as the cut point for this variable. For those survey participants aged 16 to 18 who were still attending school, years of schooling did not reflect future intent to graduate, thus introducing a potential age bias.

Employment. The U.S. Department of Labor, Bureau of Labor Statistics (2008a) defined employment as "working at least one hour of paid work; 15 hours or more paid work in family enterprise; employed but temporarily absent whether or not paid for the absence; and self-employment." Each person is counted only once, even if the person holds more than one job.

Those survey participants who responded "no" to current employment were asked, "What is the main reason you did not work last week?" (Centers for Disease

Control and Prevention, National Center for Health Statistics, 2008a). The U.S. Department of Labor, Bureau of Labor Statistics (2008a) defined unemployment as "persons available for work who had made specific efforts to find employment or those waiting to be recalled to a job following a layoff." For this study, unemployment was dichotomized as voluntary that is, those who are able to work but choose not to work, and involuntary that is, those who are unable to work for health reasons, cannot find work and/or lost their job. Voluntary unemployment included taking care of the house and/or family, going to school or retirement. Misclassification could have occurred among those survey participants who had stopped looking for a job that is, those who involuntarily retired or who are disabled and wanting to work but were not able to find suitable employment.

Lastly, a composite employment history variable was created: never employed, currently employed, employed in the past but not currently; and employed now and in the past. Missing data was included in "never employed."

Income. In accordance with the U.S. Census Bureau American Population Survey, NHANES defined family as "two or more people related to each other" (Centers for Disease Control and Prevention, National Center for Health Statistics, 2009c). It should be noted while every family is a household, not every household is a family. NHANES provided incremental incomes for households and families as well as a family poverty-to-income ratio. A family poverty-to-income ratio is equal to the family income divided by the federal poverty threshold. Each year, the U. S. Census Bureau establishes income thresholds that vary by family size and age to determine who lives in poverty. These calculations are based on Orshansky's concept of a

"market basket" where a standard budget was defined as "a list of goods and services that a family of a particular size and composition would require for a year to live at some specified level" (Assistant Secretary for Planning and Evaluation, U.S. Department of Health and Human Services, 2010; Fisher, 1997, p. 3). Poverty threshold levels are adjusted annually for inflation using the Consumer Price Index for All Urban Consumers (U.S. Department of Labor, Bureau of Labor Statistics, 2009). The federal poverty threshold has limitations. This threshold represents a level of "biological" subsistence based on minimal nutritional requirements with a fixed ratio for non-nutritional requirements. This threshold is relative to the 20th percentile of family income distribution and increases proportionately. The socially-defined minimum standard of living is not addressed (Hauver, Goodman, & Grainer, 1981; Smeeding, 2009). This federal poverty threshold level includes earned income before taxes but excludes capital gains and non-cash benefits such as food stamps, public housing and Medicaid. As a result, it underestimates total income and measures of total wealth. Additionally, these calculations ignore geographical differences which may overestimate disposable income. Despite their limitations, the federal poverty threshold and the poverty-to-income ratio are used widely as measures of income inequality (Hisnanick & Rogers, 2005) and so, subsequently, they were used in this study.

Other benchmarks of income inequality included relative poverty (60% of annual median income), low-income status (200% of the federal poverty level) and 50% of median income, the criterion used for housing assistance eligibility (U.S. Department of Housing and Urban Development, 2009). Median household and family incomes

are computed annually by the U.S. Census Bureau on the basis of a standard distribution of households and families including those with no income (U.S. Census Bureau, n.d.). For income calculations, this study referenced family median incomes from the U.S. Census Bureau (n.d.) for the first year of each two-year survey (1999 to 2000: $49,628; 2001 to 2002: $51,742; 2003 to 2004: $53,692). In this study, 6% to 11% chose not to report family or household income. It is not known how these refusals affected income-related data (Table 25).

Marital Status. In a study on marriage and women's health by Waldron, Hughes and Brooks (1996), marital status was measured as a dichotomous variable (i.e., married or living with partner versus never married, divorced, widowed or separated) because they found no differences in health among these subcategories of unmarried women aged 24 to 34. However, differences in health were found between never married and divorced or separated women at the five-year follow-up (Waldron, Weiss & Hughes, 1997). This suggested an age bias. For this study, it was decided to keep "never married" separate from "once married" (widowed, separated or divorced). Married or living with a partner were grouped together. Missing data were kept separately.

Race-Ethnicity. The Centers for Disease Control and Prevention, National Center for Health Statistics followed U.S. Office for Management and Budget standards for establishing the minimum number of categories for race and ethnicity (Centers for Disease Control and Prevention, National Center for Health Statistics, 2000). NHANES asked participants to self-identify into one category by ethnicity

(Hispanic versus Non-Hispanic) or race (Non-Hispanic White; Non-Hispanic Black; and Asian, Pacific Islander, Native American or Multi-Racial).

Approximately 58% of the U.S. Hispanic population is from Mexico or of Mexican descent (U.S. Census Bureau, 2000). Mexican Americans are purposely oversampled in NHANES. Mexican Americans were categorically differentiated from all Other Hispanics. For this study, "Mexican Americans" were merged with "Other Hispanics" into an "All Hispanics" category because of the relatively smaller cell size for "Other Hispanics".

The broadly-defined racial group "Other" may underestimate relative risk within its subgroups (Sarnquist, Moix Grieb, & Maldonado, 2009). On the other hand, this heterogeneous grouping of Asian, Pacific Islander, Native American and Multi-Racial individuals has been shown to be at increased relative risk for methylmercury exposure related to fish consumption (Hightower, O'Hare, & Hernandez, 2006).

For those participants who responded initially "don't know", NHANES asked them to choose the one category that *best* represented their ethnicity or race (Centers for Disease Control and Prevention, National Center for Health Statistics, 2000). Since race and ethnicity are social and not biological constructs, there is validity in self-identity. "People are who they say they are" (Kaufman, 1999, p. 103). Despite its imperfections, this categorical race-ethnicity variable was used in this study because it promoted statistical reliability and allowed for data comparability (Buescher, Gizlice, & Jones-Vessey, 2005).

Once all the dependent and independent variables were defined, data processing and analysis commenced.

Data Processing and Analytic Procedures

Phase One. Using SAS© and StatTransfer©, datafiles were downloaded from the NHANES website then organized and unified into one large database prior to identifying this study's population.

Organized Database. NHANES divided each two-year cycle into four sections: demographics, examination, laboratory tests and questionnaires. Each section contained many datafiles comprised of related variables. Documentation on each datafile was reviewed to identify which of them contained variables of interest. Each variable was examined in detail for relevance to this research application including population subset, skip pattern (if/then - go/to), description and range of values. Datafiles (109) for three contiguous two-year cycles (1999 to 2004) were downloaded from http://www.cdc.gov/nchs/nhanes in SAS© transport file format (.xpt) and imported into SAS© statistical software version 9.2 using StatTransfer©. The data files were merged into three separate datasets according to release years (1999 to 2000, 2001 to 2002 and 2003 to 2004), merging individual data by participant identification number (SEQN).

Codebooks were cross-checked for inconsistencies across years with regard to assigned variable names. Wherever the survey question, examination datum or laboratory test was identical across data sets but differed in variable name, the inconsistency was addressed by setting the variable name in the 1999 to 2000 and 2001 to 2002 data sets to that used in 2003 to 2004 data set. Additionally, codebooks were cross-checked for inconsistencies among answer codes. Where the question was the same but the answer codes differed across data sets, these inconsistencies were

corrected by recoding the answers to those used in the 2003 to 2004 dataset. Potential data truncation in variable length fields was avoided by using the longest of the three field lengths. Finally, these three datasets were concatenated into one large database.

Identified Study Population. Using SAS©, all gender- and age- eligible participants were identified for each of the three two-year surveys (1999 to 2004). Those participants who were interviewed, examined and tested were identified using a six-year laboratory subsample weight. Subsequently, age-eligible pregnant participants were identified. After reviewing frequencies by age, race-ethnicity and pregnancy status, it was decided that eligible participants would be required to have all seven blood tests (lead, total mercury, inorganic mercury and lipid-adjusted PCB 118, PCB 138, PCB 153 and PCB 180) and reliable dietary recall to be included in this study.

Phase Two. Using SAS©, dependent and independent variables were identified within the large unified database and prepared for data analyses.

Operationalized Dependent Variables. Lower limits of detection and imputed values were identified for each of the chemicals of interest. Initially, variables were created from detectable values only and transformed logarithmically. Subfiles containing only these values and their corresponding participant identification numbers were exported by StatTransfer© to SPSS© because the graphics interface in this software is more user-friendly and of better quality than SAS© or SUDAAN©. Histograms of log detectable values were created for each two-year survey period to check for normal distribution. In SAS©, descriptive statistics were performed. Results

were compared to Hornung and Reed (1990) criteria for imputing values below the lower level of detection.

Values for lipid-adjusted polychlorinated (PCB) congeners 118, 138/158, 153 and 180 were summed and transformed logarithmically to create a new variable, the sum of lipid-adjusted PCBs. Inorganic mercury (IHg) was subtracted from total mercury (THg) to create a new variable, methylmercury (MeHg). Negative methylmercury values were identified and imputed per Mahaffey et al. (2004). Since some of these derived values were equal to zero, a value of one was added to each data point prior to logarithmic transformation. Frequency distributions were examined before and after logarithmic transformation.

With an infinite number of possible values on the individual level, dichotomous variables were created for lead, methymercury and sum of PCBs with their respective geometric means as cutpoints. Exposure was defined as a xenobiotic blood level at or above the geometric mean. Two different exposure variables were created: one using four categories (0, 1, 2, or 3), the other using two categories (0 or 1 and 2 or more). Both of these operational definitions were conceptually congruent. There were no missing data.

Operationalized Independent Variables. Informed by Sexton, Olden and Johnson's modified environmental health paradigm (1993a) and the literature review, NHANES was scrutinized to identify measures which best represented the concepts. Independent variables of interest included specific susceptibility- and exposure-related attributes, socioeconomic factors and race-ethnicity. These measures were identified, relabeled and recoded as necessary. For example, "don't know" and "refused"

answers were recoded as "missing". Nominal categorical variables were created. Dichotomous variables were created whenever appropriate. Variable frequencies were checked (Table 26) and all 62 independent variables were assessed to assure adequate numbers met the NHANES guidelines for statistical reliability (Centers for Disease Control and Prevention, National Center for Health Statistics, 2006). As noted previously, some variables were dropped due to small cell size. Missing values were addressed on a variable-by-variable basis. Bivariate analyses were conducted on selected pairs of independent variables. Subsequently, some operational definitions were refined (Table 27).

Phase Three. Software instructions were constructed under SAS© and SAS-callable SUDAAN© for unweighted (sample population) and weighted (study population) statistical analyses, respectively. Both software programs are specifically designed for these types of survey data. To avoid biased estimates and overstated statistical significance levels, data were sorted by stratum and masked variance unit or primary sampling unit variables prior to analyses and estimates of sampling errors were calculated by the Taylor series linearization method with replacement per analytical guidelines (Centers for Disease Control and Prevention, National Center for Health Statistics, 2006).

To address this study's research questions, analyses included descriptive and univariate statistics, multivariate statistical and logistic regression modeling, and estimates of risk. Where an unweighted individual cell size was less than 30, the specific value was withheld and replaced with an asterisk per CDC NCHS

recommendations (Centers for Disease Control and Prevention, National Center for Health Statistics, 1993).

Research Questions One and Two. This study population's distribution of xenobiotic levels was analyzed using descriptive statistics including estimates of prevalence of exposure to each of the chemicals of interest. Univariate statistics for each of these xenobiotics were generated before (Tables 28 and 29) and after (Tables 30 and 31) logarithmic transformation. Crude prevalence estimates for each specific environmental chemical were derived by dividing the number of eligible women at or above the geometric mean by the total population of childbearing aged and pregnant women living in the U.S. (Tables 30 and 31). The age-adjusted prevalence was calculated by using standard adjustment techniques. During this phase of the analysis, exposures to combinations and permutations among childbearing-aged females (Table 32 and Figure 35) and pregnant childbearing-aged females (Table 33 and Figure 36) were identified. All estimates were weighted to be nationally representative using SUDAAN©. After examining these data it was decided to drop exposure as outcome in four categories (Tables 34 and 35, Figures 37 and 38) in favor of the two-category exposure variable (Tables 36 and 37, Figures 39 and 40). This dichotomous variable would assure adequate cell sizes and improve statistical reliability. All prevalence rates for childbearing-aged women and pregnant childbearing-aged women (unweighted and weighted) are summarized in Tables 38 through 41.

Research Question Three. Bivariate analyses of 54 independent variables on exposure as outcome with two categories were performed on unweighted and weighted data for childbearing-aged women (Table 42). Unadjusted (unweighted)

variables were examined primarily to determine association. All other analyses were conducted using adjusted (weighted) data. Thirty-three weighted (adjusted) independent variables with non-statistically significant *p* values ($p > 0.20$) were eliminated from further inclusion in this study (Table 43). Of the 21 remaining variables with statistically significant correlations ($p < 0.20$), four variables were dropped based on their low chi-square (χ^2) values (race-ethnicity with five categories, ever pregnant, trimester of pregnancy and seafood meals eaten in past 30 days) in favor of retaining very similar variables with higher chi-square (χ^2) values that is, race-ethnicity with four categories, live births, current pregnancy, fish and shellfish variables, respectively (Table 43).

Based on the results of the aforementioned bivariate analyses, a multivariate logistic regression exposure model was developed by creating a series of nested models and utilizing likelihood ratio testing per Hosmer and Lemeshow (2001). These stepwise regression analyses were not computer-generated. Stepwise logistic regression analysis of exposure as outcome with two categories is detailed in Table 44. The best-fit logistic regression exposure model had 13 variables (Table 45).

A variance inflation factor (VIF) test was performed to identify any collinearity beyond interaction among the independent variables using the best-fit logistic regression exposure model. No collinearity was found (Table 46).

Two-way interactions among the independent variables were assessed for inclusion by comparing nested models that is, the interaction model against another model without interaction using likelihood ratio testing per Hosmer and Lemeshow (2001). Overparameterization occurred after three sequential nested model operations

as the data were too sparse for the number of interactions. Rather than introduce prejudice to the model, efforts were redirected to identify all statistically relevant two-way interactions for future analyses (Table 47). Ten variable pairs could not be tested due to overparameterization. Nineteen pairs were not statistically significant ($p > 0.20$). For the remaining 48 pairs, 40% showed strong statistically significant interactions ($p < 0.001$). Finally, odds ratios (*OR*) were calculated with corresponding 95% confidence intervals (CI) as estimates of risk for each factor among childbearing-aged women using the best-fit exposure model with no interactions (Table 48).

In order to compare the exposure model to each of the models for lead, methylmercury and PCBs, additional data were generated. These data includes:

1. bivariate analyses of independent variables on exposure to each chemical of interest;
2. summaries of chi-square (χ^2) and *p* values;
3. stepwise logistic regression analyses;
4. variance inflation factor tests for collinearity;
5. statistical significance of interactions between independent variables and each chemical; and
6. odds ratios and confidence intervals for each best-fit logistic regression model with no interactions. (Tables 49 through 69.)

Further discussion regarding these data on specific chemicals is outside the scope of this dissertation and its research questions; these data are available for future study.

Ethical Research

All NHANES protocols were approved by the Centers for Disease Control and Prevention, National Center for Health Statistics Research Ethics Review Board and therefore assumed to be in compliance with federal regulations (Centers for Disease Control and Prevention, National Center for Health Statistics, 2010c; Protection of Human Subjects, 1991; U.S. Department of Health, Education & Welfare, National Institutes of Health, Office of Human Subjects Research, 1979, 2005).

Informed Consent of Original Survey Participants. Participants signed consent forms before the interview and the physical examination. If a child was capable, each assented to participation. Regardless of age, guardians consented to each child's participation. Participation was voluntary and an individual could withdraw at any time. Not all participants completed all survey components. Participants received compensation for their time and child or elder care if necessary as well as transportation to and from the Mobile Examination Center (Centers for Disease Control and Prevention, National Center for Health Statistics, 2010b).

Risks and Benefits to Participants in Original Survey.

Physical Risks and Benefits. A portion of survey participants received a thorough physical examination. The physical examinations posed no risk of harm or serious injury to the participants as this portion of the survey was similar to a routine physical examination.

During the laboratory examination, blood and urine samples were obtained from each participant for analysis. As a result, a venipuncture was required during which the participant would have experienced some brief pain and localized discomfort.

Blood draws posed a slight risk of harm (contusion) or injury (*in situ* infection) to the participants. To minimize these risks, venipunctures were performed by experienced healthcare personnel and universal precautions were followed per protocol.

A participant received the benefit of a thorough health assessment. This was beneficial, particularly for those who did not have routine health checkups or adequate healthcare insurance.

Psychological Risks and Benefits. The physical examination and laboratory testing took approximately 3.5 hours per person, depending upon age (details not provided). This may have fatigued participants, especially children. Conceivably, some participant responses may have been impacted by fatigue, introducing a recall bias. However, any recall bias would have minimal impact on study results due to large sample size.

Questions of a "sensitive" nature (e.g., illicit drug use and sexual behaviors) were self-administered in the privacy of participants' homes or in divided rooms within the Medical Examination Center (MEC). For results of tests considered "sensitive", participants were given a password, a toll-free number to call and the date to call. These provisions for privacy would have minimized risk of embarrassment or a reason for a participant to alter answers to questions to avoid embarrassment. Participants received a confidential medical report within 12 to 16 weeks. This equated to the benefit of an assurance of health or early diagnosis of a health problem (Centers for Disease Control and Prevention, National Center for Health Statistics, 2010c).

Financial Risks and Benefits. Participants would have incurred lost wages, if employed, for approximately 3.5 hours plus transportation time to and from MEC.

However, this loss was countered by the benefit of participants receiving compensation (amount not delineated) for their time and child / elder care if necessary as well as transportation to and from the mobile examination center (Centers for Disease Control and Prevention, National Center for Health Statistics, 2010b).

Protections Against Risk for Vulnerable Populations in Original Survey. All participants signed consent forms before the interview and the physical examination. If a child was capable, she assented to participation. Regardless of a child's capability, guardians consented to each child's participation. Participation was voluntary and an individual could withdraw at any time. The original study had the same direct benefit to children, pregnant women and their fetuses as any other study participant. The risk to the fetus and children was minimal. All NHANES protocols were approved by the CDC NCHS Research Ethics Review Board and therefore assumed to be in compliance with Subpart B (Protection of Human Subjects, 2001) and Subpart D (Protection of Human Subjects, 1983).

Confidentiality in Original Survey. Initial interviews were conducted with participants within the privacy of their own homes. Within the MEC, there were divided rooms to assure privacy. Participants received a confidential medical report within 12 to 16 weeks. For results of tests considered "sensitive", participants were given a password, a toll-free number to call and the date to call. Although NHANES assigned an identification number to each survey participant, to maintain anonymity, they did not publicly release details. For example, geography, genetic data and detailed age- or income-specific data which could have identified or assisted in the identification of individual survey participants were not released to the public. To

maintain confidentiality, NHANES used masked variance units, a collection of secondary sampling units aggregated into groups for the purpose of variance estimation (Centers for Disease Control and Prevention, National Center for Health Statistics, 2010b). NHANES de-identified all data to preserve confidentiality and protect its survey participants. For purposes of this study, HIV/AIDS-related information was incorporated into a more comprehensive variable (co-morbidities). Since the cell size was small, the specific number of cases was not released. This researcher did not add to the original dataset.

Dissertation Data Sharing and Release. This dissertation research used de-identified data with no access to personal identifiers. The database was already publicly and freely available. As a result, there was no need to request authorization for use and disclosure of protected health information (PHI). However, data were stored on a laptop computer as well as multiple 2-GB and one 16-GB flash memory drives. This researcher had continual data access. Faculty had access to the data if and when access to data was needed, particularly during data analysis. Files were shared electronically or hard copied. Results of the research will be released in a timely manner, completely and as accurately as possible following appropriate peer review. Raw data and analyses will be kept for at least three years.

Dissertation Research Results Sharing Plan. Sharing research results is essential to expanding the body of knowledge in environmental health, public health and nursing. The results of this research will be published as a dissertation in partial fulfillment of the requirements for a Doctorate in Philosophy (PhD) from the University of Rhode Island, College of Nursing and available through ProQuest©.

Subsequently, it is the intent of this researcher to submit for publication a number of articles (two or three minimally) related to this research and research findings to peer-review journals such as Journal of American Public Health Association (APHA), Environmental Health Perspectives (EHP), Journal of Epidemiology, Journal of Association of American Occupational Health Nurses (AAOHN) and/or Professional Safety (ASSE). Additionally, proposals (two minimally) will be submitted to present research findings and related topics at these associations' national, regional and/or state conferences.

Institutional Review Board. This study involved descriptive, univariate and multivariate analyses of existing retrospective data (1999 to 2004) from the National Health and Nutrition Examination Survey (NHANES). These data were publicly available and freely distributed online (http://www.cdc.gov/nchs/nhanes.htm). This researcher did not add to the dataset. The University of Rhode Island (URI) had an approved assurance of compliance on file with the Department of Health and Human Services which covered this research activity (FWA 00003132). Because this research was a secondary data analysis, the dissertation proposal was reviewed by the Chair of the Institutional Review Board and deemed it exempt ("not human subjects research") on December 30, 2009 (Appendix G: University of Rhode Island Institutional Review Board on Human Subjects IRB Action Report). The Rhode Island Department of Pubic Health signed an individual investigator agreement on January 12, 2010 (Appendix H: Rhode Island Department of Health Individual Investigator Agreement).

Chapter Summary

Every aspect involving the methodologies used in this dissertation have been described in detail: the operationalization of all dependent and independent variables, validity and reliability of these measures, analytic procedures and ethical protocols. The next chapter begins with a general description of the study population then addresses the results and limitations for each research question before concluding with a discussion. Additionally, comparisons between the best-fit logistical regression exposure model and each chemical's best-fit logistical regression model are drawn and discussed.

CHAPTER 4

FINDINGS

This chapter begins with a general description of the study population subset regardless of xenobiotic blood levels. These findings are made available for reference only and will not be discussed further (Tables 26, 27, 36 and 37). Subsequent to this general description, the findings for each research question are revealed. After a comparison between the best-fit logistic regression exposure model and the best-fit logistic regression model for each individual chemical, the discussion section concludes with reference to Sexton, Olden and Johnson's modified environmental health paradigm (1993a).

For ease of readability, this study's findings are reported in this chapter with references to weighted (adjusted) data only, rounded to the nearest whole number. Both weighted and unweighted data can be found in the tables referenced in this chapter. "Unweighted" data are raw data collected from NHANES participants. There were two sample (unweighted) populations: all male and female NHANES participants (1999 to 2004) and a subset consisting of 3,173 childbearing-aged female participants who were interviewed, examined, tested for all chemicals of interest and deemed to have reliable dietary recall. This subset of childbearing-aged females included 491 who were pregnant at time of their examination. "Weighted" data is raw data that has been adjusted to represent an entire population. There were two study (weighted) populations: all people living in the U.S. (1999 to 2004) and a subset

consisting of 134,502,033 childbearing-aged females living in the U.S. (1999 to 2004) of whom 4,842,189 were pregnant. Only this study population subset is reported in this dissertation unless otherwise specified.

The reader is reminded that dependent variables appear in tables in a consistent order: lead, methylmercury, then the summed value of four specific lipid-adjusted polychlorinated biphenyl congeners 118, 138/158, 153 and 180. Independent variables appear in tables in a consistent order that correlates with Sexton, Olden and Johnson's (1993a) modified environmental health paradigm (Figure 2).

General Description of the Study Population Subset

Fourteen percent of childbearing-aged women were 16 to 19 years old, 34% were ages 20 to 29, 27% were 30 to 39 years old, and 25% were ages 40 to 49. Seventy-three percent were Non-Hispanic White, 10% Non-Hispanic Black, 6% Mexican-American, 6% Other Hispanics (12% All Hispanics) and 5% were Asian, Pacific Islander, Native American or Multi-Racial (Table 7).

Of these childbearing-aged women, 4% were pregnant at the time of their examination. Eight percent of these pregnant women were 16 to 19 years old, 53% were ages 20 to 29, 35% were 30 to 39 years old, and 4% were ages 40 to 49. Sixty-three percent were Non-Hispanic White, 15% Non-Hispanic Black, 10% Mexican-American, 5% Other Hispanics (15% All Hispanics) and 7% were Asian, Pacific Islander, Native American or Multi-Racial (Table 12).

Susceptibility-Related Attributes.

Reproductive Status. Overall, half of the childbearing-aged women had given birth to one or more live children; 4% were currently pregnant. Thirty-two percent of

childbearing-aged women had breastfed one or more children for at least one month and/or was currently breastfeeding. Breastfeeding was correlated with age ($p < 0.000$).

Health Status. Overall, childbearing-aged women were healthy. Only 8% perceived their health to be fair or poor. Approximately 12% had one or more co-morbidities. Of those with more than one co-morbidity, 25% perceived their health to be fair or poor. Iron deficiency was found in 9% of these women. Approximately 8% of those iron deficient had not been diagnosed or received medical treatment for anemia in the prior three months. Sixteen percent had no health insurance. Fifty-one percent of those with private health insurance used the emergency room or hospital outpatient department as their regular source of healthcare. Of those who did not have health insurance, 40% used the emergency room or hospital outpatient department regularly for their healthcare.

Nutritional Status. Eleven percent of these women were identified as food insecure. Among those found to be food insecure, 18% were obese (i.e., body mass index of 30.0 or more). This percentage of obesity among food insecure women was slightly lower than that for overall obesity (26%). Forty percent of the study population subset exceeded daily fat intake requirements while 12% did not meet daily intake requirements for protein. The percentages of those who failed to meet minimum daily intake requirements for iron, calcium and selenium were 75%, 68% and 16%, respectively. Those women who met or exceeded selenium requirements were somewhat more likely to have eaten seafood (85%) than not (76%) in the previous 30 days.

Exposure-Related Attributes.

Acculturation. Eleven percent of childbearing-aged women were born outside the United States. Of these women, 8% had lived in the U.S. for more than five years and 2% lived in the U.S. for less than five years. Of the three percent of childbearing-aged women who spoke a language other than English at home, 65% of these women had lived in the U.S. five yearsor more and 28% had lived in the U.S. less than five years. There was a statistically significant correlation between language spoken at home and U.S. citizenship ($p < 0.000$).

Dietary Consumption. Seventeen percent of childbearing-aged women did not eat any fish or shellfish meals within the prior 30 days while 43% ate both fish and shellfish in this same time period. There were 25% more fish eaters than shellfish eaters. Only 12% of these women drank 2,000 ml or more of residential tap water in the previous 24 hr. Thirty percent of childbearing-aged women reported no water intake from this source.

Alcohol Consumption. One-third reported drinking at least twelve alcoholic drinks in any one year and at least one drink in the prior 30 days. Another 27% reported drinking five or more drinks of any alcoholic beverage in any one day and/or almost every day within the span of the previous twelve months. Drinking correlated with serum cotinine levels ($p < 0.024$).

Tobacco Use. The majority (74%) of childbearing-aged women had serum cotinine levels lower than 1 ng/dl while a much smaller percentage (22%) had levels greater than 10 ng/dl. Serum cotinine levels correlated significantly with both self-reported tobacco use and reported environmental tobacco smoke exposure ($p < 0.000$).

Twenty percent of women aged 16 to 19 for whom self-reported tobacco use was withheld from public release had serum cotinine levels higher than 10 ng/ml. At this level, they were most likely current smokers.

Residential Characteristics. Residential water treatment systems were more prevalent when sources of tap water were public (83%) than private (16%). Only eleven percent drew their tap water from private sources. Of the women who consumed 2,000 ml or more of tap water, an equal percentage (12%) drew their water from public or private sources. Two-thirds of childbearing-aged women lived in detached or attached housing of which 90% were owned. Only 7% resided in mobile homes or trailers. Thirty-six percent of renters and 41% of those residing in alternate living arrangements did not know the age of their residence. Among those women who knew the age of their residence, 24% of residences were built before 1960 and another 17% were constructed between 1960 and 1978. Renters were more likely to have lived in their current residence less than five years (89%) than home owners (50%). Household size (i.e., the total number of family members) correlated with the number of rooms in the residence ($p < 0.000$). Only 7% of households with four or more persons lived in less than four rooms.

Occupation. Approximately half of working childbearing-aged women held management, professional or sales-related occupations. These women were four times more likely to have held a job for more than five years than those women in the services- and goods-related occupations. Of those who worked longest in the services- and goods-related occupations, 39% had worked more than five years. Women working in this occupational grouping were four times more likely to live at or below

the U.S. poverty threshold level than those who worked in the management, professional and sales-related occupations. Among those who were not working (31%), twice as many lived above the U.S. poverty threshold level (65%) than at or below this level (28%).

Socioeconomic Factors.

Education. One fifth of childbearing-aged women had less than a high school education. The percentage of women with a high school diploma, GED or higher was 86 to 89% within each age cohort except for those aged 16 to 19, some of whom had not yet completed their education. While age was correlated with educational level ($p < 0.000$), there was no statistically significant interaction between education and age in terms of exposure risk. Those women who had less than a high school education were twice more likely to live at or below U.S. poverty threshold level.

Employment. Employment rate was 69%. Forty-one percent worked 35 hours or more per week. Among those who were unemployed, 21% did so voluntarily; 6% had never worked. Women aged 20 and older who had a high school diploma, GED or higher were three times more likely to be employed than unemployed. In contrast, women of the same age who did not have a high school diploma or GED were equally as likely to be employed (56%) as unemployed (44%). Sixty-seven percent of married women were working.

Income. Of the 17% who lived at or below the U.S. poverty threshold level, 43% were aged 20 to 29. Twenty-one percent of 16 to 19 year olds lived at or below this level. Slightly more than half of the childbearing-aged women who lived at or below the U.S. poverty threshold level either had never married or were widowed, divorced

or separated. Eighty-six percent of women who were married or living with a partner lived above this level.

Marital Status. Forty-six percent of childbearing-aged women were married or living with a partner (46%); 40% had never married and 11% were widowed, divorced or separated. Marital status was significantly correlated with age ($p < 0.000$). Twenty-five percent of Non-Hispanic Black women were married or living with a partner as compared to 50% of Non-Hispanic Whites and 40% of Hispanics.

Race-Ethnicity. Non-Hispanic Blacks and Hispanics were 50% less likely to have a high school diploma or GED. Twice as many Non-Hispanic Blacks and more than 7% of Hispanics lived at or below the U.S. poverty threshold than above it. Of those who were unemployed, Non-Hispanic Black women were twice as likely to be involuntarily unemployed as Non-Hispanic White or Hispanic women. Thirty-six percent of Hispanic women were unemployed voluntarily versus 20% Non-Hispanic Whites and 16% Non-Hispanic Blacks. Age was correlated with race-ethnicity ($p < 0.04$). There were no statistically significant differences among racial and ethnic groups with regard to the type of residence but there was a statistically significant difference ($p < 0.006$) among these groups as to whether they owned or rented their home. Missing data on age of residence precluded further analysis.

Findings

Research Question One. What was the prevalence of childbearing-aged and pregnant childbearing-aged women's exposures to each of the following environmental chemicals: lead, methylmercury and polychlorinated biphenyls (PCBs) as measured by chemical-specific (xenobiotic) levels at or above geometric mean in

blood or serum of these women who were living in the United States from 1999 through 2004?

Among childbearing-aged females, the prevalence rates for xenobiotic blood or serum levels at or above the geometric mean were 49 per 100 for lead, 48 per 100 for methymercury, and 67 per 100for PCBs (Table 30). The number of childbearing-aged females above the 99th percentile was approximately 3 million, 2 million and 1.8 million for lead, methylmercury and PCBs, respectively (Table 29). Among those who were pregnant, prevalence rates were 25 per 100, 33 per 100, and 50 per 100 for lead, methylmercury and PCBs, respectively (Table 30). The number of pregnant females above the 99th percentile was approximately 433,000 for lead, 190,000 for methylmercury, and 21,000 for PCBs (Table 29).

Research Question Two. What combinations and permutations of chemical exposures were most common among these childbearing-aged and pregnant childbearing-aged women as evidenced by xenobiotic blood or serum levels at or above the geometric mean?

Approximately 20% – one fifth – of childbearing-aged females had xenobiotic blood levels at or above the geometric mean for all three chemicals. For the 38% of these women who had two xenobiotic blood levels at or above the geometric mean, it was equally likely to be methylmercury and PCBs (44%) or PCBs and lead (43%) as it was lead and methylmercury (14%). Among the 26% of childbearing-aged females having one xenobiotic blood level at or above the geometric mean, it was twice more likely to be PCBs (51%) than either lead (28%) or methylmercury (21%). Sixteen percent of childbearing-aged females had no xenobiotic blood levels at or above the

geometric mean (Table 32, Figure 35.) There was only a 4% difference between those childbearing-aged females with no xenobiotic blood level at or above the geometric mean and those with three xenobiotic blood levels at or above the geometric mean.

Only 6% of pregnant childbearing-aged females had xenobiotic blood levels at or above the geometric mean for all three chemicals. For the 36% of those who had two, it was highly likely that it was methylmercury and PCBs (74%) than either PCBs and lead (18%) or lead and methylmercury (8%). Among the 25% of these women who had one, it was more likely that it was PCBs (42%) or lead (39%) than methylmercury (19%). Thirty-three percent of pregnant childbearing-aged females had none (Table 33, Figure 36.) There was a 27% difference between those pregnant childbearing-aged females with no xenobiotic blood level at or above the geometric mean and those with three xenobiotic blood levels at or above the geometric mean.

Table 32
Combinations and Permutations of Exposures: Number of Childbearing-Aged Females[1] with Xenobiotic Blood Levels At or Above the Geometric Mean (unweighted and weighted data 1999-2004)

	0	1	2	3
Total Number of Chemicals At or Above Geometric Mean				
Frequency $_{unweighted}$	702.00	971.00	1,005.00	495.00
Row Pct.	(22.12%)	(30.60%)	(31.67%)	(15.60%)
Frequency $_{weighted}$	20,889,388.72	35,175,071.94	51,205,786.00	27,231,786.77
Row Pct.	(15.53%)	(26.15%)	(38.07%)	(20.25%)
Total Number of Chemicals At or Above Geometric Mean				
Frequency $_{unweighted}$				
Col. Pct.				
Frequency $_{weighted}$				
Col. Pct.				
	702.00			
	(100.00%)			
All Xenobiotic Blood Levels	20,889,388.72			
Below Geometric Mean	(100.00%)			
		371.00		
		(38.21%)		
Lead Only		9,875,692.09		
At or Above Geometric Mean		(28.08%)		
		229.00		
		(23.58%)		
Methylmercury Only		7,218,046.91		
At or Above Geometric Mean		(20.52%)		
		371.00		
		(38.21%)		
Sum of PCBs Only		18,081,332.94		
At or Above Geometric Mean		(51.40%)		
			191.00	
			(19.00%)	
Lead and Methylmercury			7,027,018.85	
At or Above Geometric Mean			(13.72%)	
			347.00	
			(34.53%)	
Methylmercury and Sum of PCBs			22,339,886.83	
At or Above Geometric Mean			(43.63%)	
			467.00	
			(46.47%)	
Sum of PCBs and Lead			21,838,880.31	
At or Above Geometric Mean			(42.65%)	
				495.00
				(100.00%)
All Xenobiotic Blood Levels				27,231,786.77
At or Above Geometric Mean				(100.00%)

[1] included pregnant childbearing-aged females

[2]where the third xenobiotic is below geometric mean

Figure 35. Number of Childbearing-Aged Females in U.S. with Xenobiotic Blood Levels At or Above the Geometric Mean (weighted data 1999-2004)

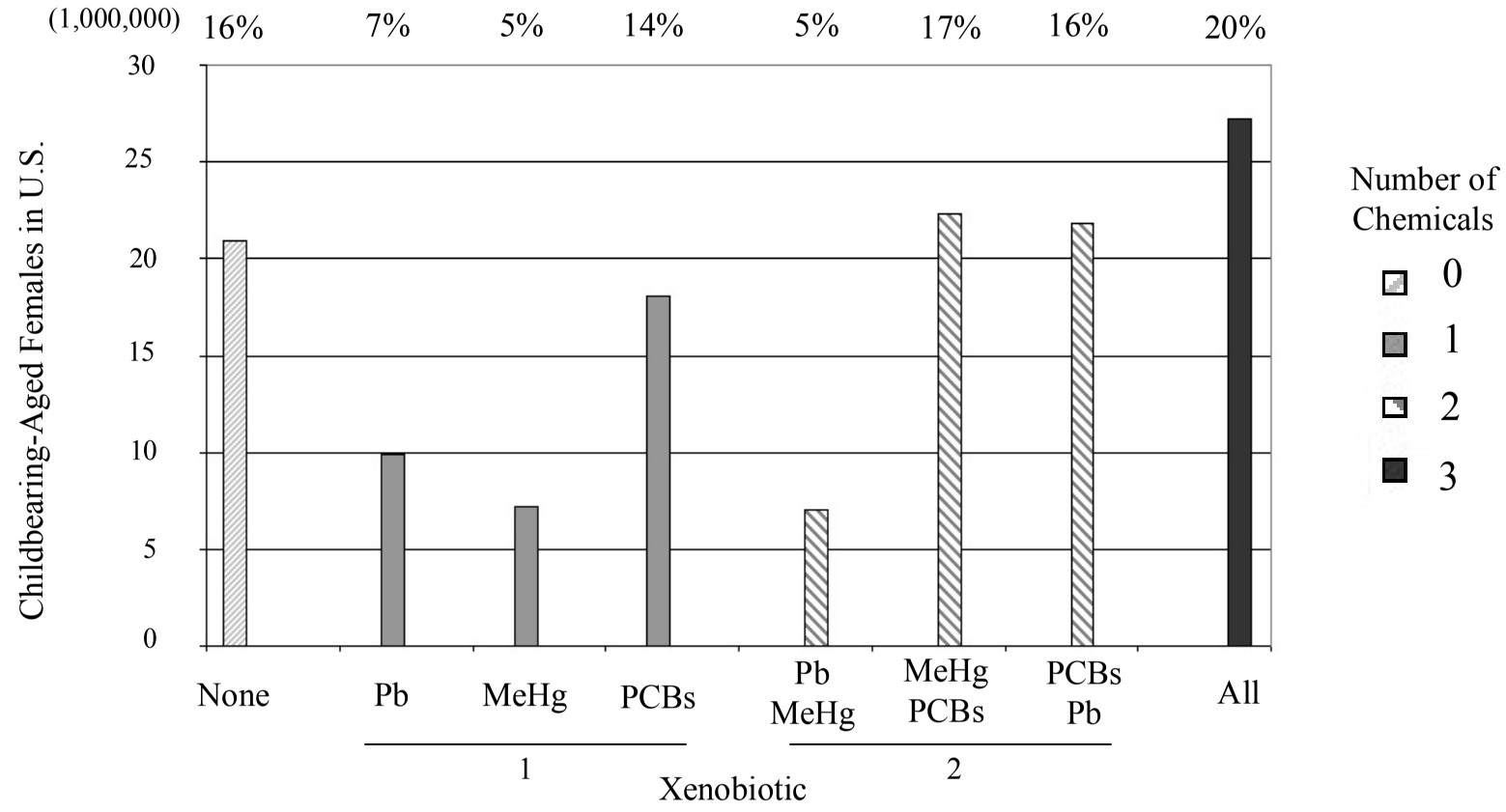
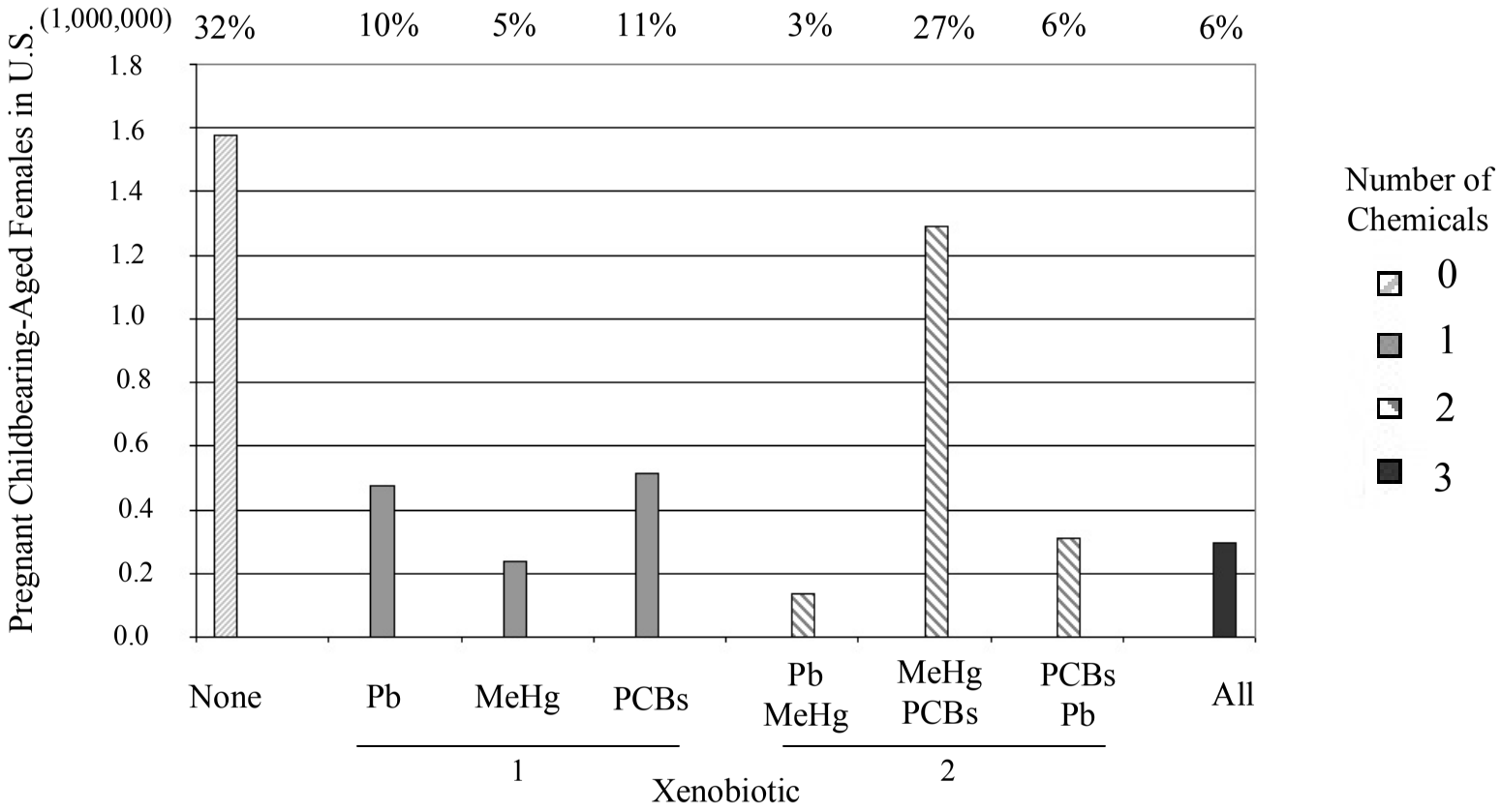


Table 33
Combinations and Permutations of Exposures: Number of Pregnant Childbearing-Aged Females with Xenobiotic Blood Levels At or Above the Geometric Mean (unweighted and weighted data 1999-2004)

Total Number of Chemicals At or Above Geometric Mean	0	1	2	3
Frequency $_{unweighted}$	137.00	118.00	110.00	*
Row Pct.	(35.64%)	(3.18%)	(28.13%)	(0.00%)
Frequency $_{weighted}$	1,575513.12	1,231,170.80	1,738,373.16	297,132,00
Row Pct.	(32.54%)	(25.43%)	(35.90%)	(6.13%)
Total Number of Chemicals At or Above Geometric Mean				
Sample Frequency $_{unweighted}$				
Col. Pct.				
Population Estimated Frequency $_{weighted}$				
Col. Pct.				
All Xenobiotic Blood Levels Below Geometric Mean	137.00 (100.00%) 1,575,513.12 (100.00%)			
Lead Only At or Above Geometric Mean		51.00 (43.22%) 477,587.57 (38.79%)		
Methylmercury Only At or Above Geometric Mean		33.00 (27.97%) 239,178.70 (19.43%)		
Sum of PCBs Only At or Above Geometric Mean		34.00 (28.81%) 514,404.53 (41.78%)		
Lead and Methylmercury At or Above Geometric Mean[1]			* (0.00%) 135,932.33 (7.82%)	
Methylmercury and Sum of PCBs At or Above Geometric Mean[1]			56.00 (50.91%) 1,292,921.09 (74.38%)	
Sum of PCBs and Lead At or Above Geometric Mean[1]			40.00 (36.36%) 309,519.74 (17.80%)	
All Xenobiotic Blood Levels At or Above Geometric Mean				* (100.00%) 297,132.00 (100.00%)

[2]where the third xenobiotic is below geometric mean

Figure 36. Number of Pregnant Childbearing-Aged Females in U.S. with Xenobiotic Blood Levels At or Above the Geometric Mean (weighted data 1999-2004)



Research Question Three. What, if any, subsets of childbearing-aged women were disproportionately exposed to two or more of these environmental chemicals based on susceptibility-related attributes (reproductive status, age, health and nutritional status), exposure-related attributes related to acculturation, proximity (residential characteristics and occupation), activity (diet and tap water supply) and behavior (alcohol consumption and tobacco use); socioeconomic factors (education, employment, income and marital status) and race-ethnicity?

The best fit logistic regression exposure model without interactions included 13 independent variables (in order of ascending *p* values and descending χ^2 values): any fish consumption in the past 30 days, age, food security, ever breastfed, highest education level attained, any shellfish consumption in the past 30 days, marital status, selenium intake/RDA, time in longest employment, alcohol consumption, household size, serum cotinine and race-ethnicity with all Hispanic grouping (Table 45).

There were three notable findings regarding relative risk for exposure with fish consumption, age and breastfeeding (Table 48).

1. Any fish consumption in the past 30 days tripled the odds of two or more xenobiotic blood levels at or above the geometric mean 95% CI [1.9, 4.9] when compared to no fish consumption during this same time period (Figure 41).

2. The odds of having two or more xenobiotic blood levels at or above the geometric mean rose non-linearly with age. From *OR* = 1.0 for ages 16 to19, to *OR* = 3.5, 95% CI [1.6, 7.9] for ages 20 to 29; *OR* = 8.5, 95% CI [3.2, 22.7] for ages 30 to 39; and finally, *OR* = 30.2, 95% CI [8.4, 109.2] for ages 40 to 49 (Figure 42).

3. Those women who were currently breastfeeding or had ever breastfed a child for more than one month were 44% less likely 95% CI [0.34, 0.93] to have two or more xenobiotic levels at or above the geometric mean than those who had never breastfed (Figure 43).

The odds of having two or more xenobiotic levels at or above the geometric mean was slightly higher for Non-Hispanic Blacks, *OR* = 1.08, 95% CI [0.56, 2.11] but slightly less for Hispanics, *OR* = 0.67, 95% CI [0.39, 1.15] and Asian, Pacific Islander, Native American or Multi-Racial, *OR* = 0.59, 95% CI [0.15, 2.32] as compared to Non-Hispanic Whites. The relative risk for exposures to multiple environmental chemicals among Hispanics and Asian, Pacific Islander, Native American or Multi-Racial was most likely underestimated due to small cell size.

It should be noted that 53% of women with two or more xenobiotic levels at or above the geometric mean worked in management, professional or sales-related occupations, 17% services- and goods-related occupations and 30% did not work at all. Data regarding occupationally-related exposures were inadequate to sufficiently assess for workplace chemical exposures.

Missing data factored into the odds ratios for marital status and food security. The significance of this missing data on results would infer that those who declined to answer these questions were somehow different than those who did answer these questions; no further explanation is offered at this time.

Comparison of Risk Factors Across Models. In an effort to better understand the origins of the risk factors that comprised the exposure model, the best-fit logistic regression exposure model with no interactions was compared to each of the best-fit

models with no interactions for lead, methylmercury and PCBs (Table 70). Variable by variable, there appeared to be no discernable pattern(s) across models. There were two notable findings regarding education and current pregnancy.

1. Education was found to be a risk factor in the exposure model but not in each chemical model. The odds of having two or more xenobiotic blood levels at or above the geometric mean were twice more likely if a childbearing-aged woman did not have a high school diploma or GED, *OR* = 1.96; CI [0.98, 3.93].

2. Conversely, current pregnancy was strongly protective in the lead, *OR* = 0.30; 95% CI [0.1, 0.7], methylmercury, *OR* = 0.65; 95% CI [0.4, 1.1] and PCBs, *OR* = 0.60, 95% CI [0.3, 1.3] best-fit logistic regression models (Table 71, Figure 44).

Modified Environmental Health Paradigm. This study tested the modified environmental health paradigm (Sexton et al., 1993b, p. 714) by exploring the interrelationships between exposure as outcome in two categories and 54 measures of vulnerability (susceptibility- and exposure-related attributes, socioeconomic factors and race-ethnicity). The goodness-of-fit for the final exposure model with no interactions was "fair" (r^2 = 0.27). It was about the same for lead (r^2 = 0.26), slightly less for methylmercury (r^2 = 0.23) but slightly higher for PCBs (r^2 = 0.35). (Table 70). This study was unable to fully test this paradigm with these models.

Discussion

Research Question One. Exposures to lead, methylmercury and PCBs were widespread among childbearing-aged and pregnant childbearing-aged women. While PCBs was the most prevalent xenobiotic overall, a relatively smaller number of

women had levels above the 99th percentile. In contrast, there were much larger numbers of women above the 99th percentile for lead and methylmercury. These findings would suggest a more widespread environmental exposure to PCBs among childbearing-aged and pregnant childbearing-aged women but disproportionately higher exposures to lead and methylmercury among among subgroups of the study population.

Other than NHANES, there are few population-based studies among women of childbearing-age in the U.S. to which comparisons can be made. In 2004, data compiled from 37 states participating in CDC's Adult Blood Lead Epidemiology and Surveillances (ABLES) Program indicated a prevalence rate of 60 per 100 (with blood lead levels ≥ 40 μg/dl among women aged 16 to 44 years (Calvert, 2007). Their prevalence rate is 11% higher than the prevelance rate calculated for this study. This difference is most likely due to an inherent selection bias in the ABLES program that is, the women tested had either lead-related occupations and/or clinically-suspected non-occupationally-related lead exposures. There were no comparable state monitoring programs identified for methylmercury or PCBs.

The National Center for Environmental Health publishes a report biennially on human exposures to environmental chemicals in the U.S. based on NHANES data (Centers for Disease Control and Prevention, National Center for Environmental Health, 2010). However, for each two-year dataset, geometric means and percentiles for specific xenobiotics are published in separate tables for gender, broad age cohorts (i.e., 12 to 19; 20 and older), and three racial-ethnic groups (i.e., Non-Hispanic

Whites, Non-Hispanic Blacks and Mexican-Americans). As a result, comparisons to these data were not possible.

Research Question Two. The magnitude of exposures to these environmental chemicals is reflected in this study's finding that 58% of childbearing-aged women (Figure 39) and 42% of pregnant women (Figure 40) had two or more xenobiotic blood levels at or above the geometric mean. Unfortunately, lead, methylmercury and PCBs represent only a fraction of all environmental chemicals to which these women were exposed. Across chemical classes such as pesticides and phthalates, Woodruff, Zota and Schwartz (2011) have documented detection of 4 to 50 chemical analytes in blood samples of pregnant and non-pregnant women.

PCBs and Lead. The binary chemical combination of PCBs and lead was identified in 17% of childbearing-aged women who had two xenobiotic levels at or above the geometric mean. In their study of adolescent girls, Denham et al. (2005) found a statistically significant interaction between these two chemicals ($p < 0.05$). Neither ATSDR nor others has assessed this chemical pair for toxicological interactions.

Methylmercury, PCBs and Fish Consumption. Another binary chemical combination, methylmercury and PCBs was identified in 27% of those who were pregnant. As discussed in Chapter Two, ATSDR (2004) predicted a greater-than-additive interaction between these two chemicals. Domestic and imported seafood and freshwater fish are primary sources of methylmercury and PCBs for adults. In this study, the strongest risk factor for two or more xenobiotic blood levels at or above the geometric mean was any fish consumption within the prior 30 days. In 2003, a

concerted effort was initiated by federal and state agencies to educate people, and in particular pregnant women, about avoiding predatory species of fish in which the biomagnification of methylmercury and PCBs was greatest. In 2009, three states (ME, RI, WA) participating in CDC's Pregnancy Risk Assessment Monitoring System (PRAMS) asked pregnant women routinely about whether their healthcare professionals counsel them about fish consumption, mercury exposure and the potential for adverse fetal outcomes (Centers for Disease Control and Prevention, 2004). In 2009, there was a 73.6% (weighted) positive response (T. Stancil, personal communication, January 26, 2011).

Research Question Three.

Age. The odds of having two or more xenobiotic blood levels at or above the geometric mean rose non-linearly with age. This study confirmed previously reported findings of a strong correlation between age with PCBs (Axelrad, Goodman, & Woodruff, 2009) and age with lead (Mushak, 1998). Bioaccumulation of these xenobiotics could explain this non-linear rise. While this study was able to confirm a statistical correlation of age with methylmercury (Caldwell, Mortensen, Jones, Caudill, & Osterloh, 2009), the relationship remained essentially unchanged with advancing age (Table 72). This may indicate a relatively larger influence of more recent exposures than those associated with long-term bioaccumulation of methylmercury.

The oldest cohort of women (aged 40 to 49) had an exponential risk, $OR = 30.2$, 95% CI [8.4, 109.2] for two or more xenobiotic blood levels at or above the geometric mean. This cohort was born from 1950 to 1963 during a time when occupational and

environmental contamination went unabated (Table 73). If historical emissions are a valid explanation, women older than 49 may have equally high or higher xenobiotic levels, though differences may be due to longer bioaccumulation. NHANES tests women aged 49 to 69 for some but not all of these xenobiotics and for some but not all the years involved in this study. While five studies (Western New York, Mount Sinai, Yale, Campaign Against Cancer and Stroke and the Nurses' Health Study) have examined blood for lipid-adjusted levels of PCB congeners 118, 138, 153, 180 in women as old as 90 (Laden et al., 2001), data correlating xenobiotic levels with age by decade were not available for comparison. A search of the scientific literature (PUBMED) have not identified any women's health studies involving methylmercury or lead among older women. To date, there are no known plans to incorporate biomarkers for these chemicals in the National Women's Health Initative (Z. Chen, personal communication, December 6, 2010).

Conversely, if historical emissions are a valid explanation, with the advent of occupational and environmental regulation and remediation in the 1970s, one would expect to find ever decreasing xenobiotic levels among successive cohorts of childbearing-aged women in subsequent survey years. The National Children's Study is a prospective longitudinal study begun in late 2009 that will examine the effects of environmental influences on the health and development of more than 100,000 U.S. children beginning preconceptually or prenatally through age 21 (Children's Health Act of 2000). It is unknown whether maternal postnatal exposures will be addressed.

Breastfeeding. In contrast to age and fish consumption, breastfeeding appeared to be protective for childbearing-aged women, *OR* = 0.56, 95% CI [0.34, 0.93]. These

odds applied to women who were currently breastfeeding as well as those who had ever breastfed at least one child for one month or more. Since all three chemicals have been measured in breast milk (Agency for Toxic Substances and Disease Registry, 2004; Bjornberg et al., 2005; Dórea, 2004), transfer of these chemicals from mother to infant-child via lactation is a likely explanation. There was no statistically significant interaction found between ever breastfed and age with the best-fit exposure model.

Current Pregnancy. Overall, women who were pregnant had lower prevalence rates than those of childbearing-aged women. This study confirms findings of Woodruff, Zota and Schwartz (2011) who found xenobiotic levels to be lower among pregnant women than non-pregnant women in their analyses of NHANES 2003 to 2004. The percentage of pregnant women with all three xenobiotic levels at or above the geometric mean was significantly lower (6%) than that of childbearing-aged women (20%). There are four possible explanations.

1. Those who were pregnant modified their lifestyles to decrease their exposures to these environmental chemicals. For example, pregnant women are advised routinely by their obstetricians to stop smoking. Based on data from 26 states, CDC estimated 13% of women reported smoking during the last three months of pregnancy (Centers for Disease Control and Prevention, 2004). This is compared to 22% of all childbearing-aged women in this study (as assessed by cotinine > 10.0 ng/ml). In this study, cotinine was associated with higher lead levels. Additionally, cotinine was one of the significant risk factors for having two or more xenobiotic blood levels at or above the geometric mean. Interaction between current pregnancy and cotinine was not statistically significant when tested with the lead model. This

interaction could not be tested in the exposure model because current pregnancy was dropped during the logistic regression analysis. Woodruff, Zota and Schwartz (2011) found relatively higher blood levels of lead and cotinine in non-pregnant women than pregnant women. In this study, while methylmercury ranked third most prevalent among childbearing-aged females, it ranked second among those who were pregnant. This rise in rank may have reflected more accurately the relatively lower level of lead among pregnant women who stop smoking.

2. These chemicals transferred from the women to their fetuses via the placenta and umbilical cord. In a study by Butler et al. (2006), maternal blood methylmercury levels were significantly lower than those in umbilical cord blood ($p < 0.0001$). Similar findings have been reported in other studies and reviewed elsewhere (Hamada, Arimura, & Osame, 1997). While it has been found to be generally true that maternal blood lead levels are significantly higher ($p < 0.0001$) than umbilical cord levels (Butler Walker et al., 2006), other studies have reported higher umbilical cord blood lead levels than maternal lead levels in approximately 25% to 28% of subjects. A study by Harville et al. (2005) attributed this phenomenon to maternal alcohol consumption. As stated in Chapter Two, alcohol has been shown to potentiate blood lead levels in animal studies (Gupta & Gill, 2000). This study could not confirm findings from Harville et al. (2005) as the interaction of alcohol consumption and current pregnancy experienced overparameterizaton when tested with the lead model. While the low lipid content of cord blood prevents similar comparisons with PCBs levels, some studies (Bergonzi et al., 2009; Wang, C. Y., et al.

2009; Wang, R., Jain, Wolkin, Rubin, & Needham, 2009) have reported higher lipid-adjusted PCB levels in maternal serum than those levels found in the placenta.

3. Age acted as an effect modifier for current pregnancy. As previously discussed in Chapter Two, studies have found maternal age to be correlated with umbilical and placental xenobiotic blood levels. Axelrad and Cohen (2010) contended that equal weighting for all age cohorts may produce a biased estimate of exposure. In other words, younger women have lower xenobiotic blood levels than older women but younger women are more likely to get pregnant than older women. In this study, only 4% of those who were pregnant were 40 to 49 years old. Age was found to be a significant predictor of two or more xenobiotic blood levels at or above the geometric mean while current pregnancy was not. While this study documented overall lower prevalence rates of each chemical among pregnant women as compared to childbearing-aged females, it could neither test for interaction between age and pregnancy with any of the regression models due to overparameterization nor confirm age as an effect modifier due to small cell size.

4. Plasma volume expansion (hemodilution) during pregnancy may have underestimated xenobiotic levels (Faupel-Badger, Chung-Cheng, Troisi, Lagiou, & Potischman, 2007). Serum albumin has been used as a surrogate for measuring plasma volume expansion by Woodruff, Zota and Schwartz (2011). When adjusted for serum albumin, the geometric means of some persistent chemicals increased while others did not change (chemicals not specified).

Comparison of Risk Factors Across Models. As stated previously, there were no discernable patterns when the best-fit logistic regression exposure model with no

interactions was compared to each of the best-fit models with no interactions for lead, methylmercury and PCBs (Table 70). There were two anomalies regarding the "appearance" of education and the "disappearance" of current pregnancy across models. One possible explanation may be differences in the operational definitions of the dependent variable across models. One xenobiotic level at or above the geometric mean was defined in the individual chemical models as "exposed" but defined as "not exposed" in the multiple chemical exposure model. One xenobiotic level at or above the geometric mean represented 26% of the data. Twice as many pregnant women had no xenobiotic blood level at or above the geometric mean than childbearing-aged women. The percentages of those with one or two chemicals at or above the geometric mean were about the same. Without further analysis, it is unknown to what extent this classification could account for the other differences seen across these models. If one chemical is the defining difference between models, it underscores the importance of studying the phenomenon of multiple environmental chemical exposures.

Modifed Environmental Health Paradigm. This study was unable to fully test the paradigm with these models. Overparameterization prevented interactions from being included in the models. There were numerous statistically significant ($p < 0.001$) interactions identified with the exposure (26), lead (29), methylmercury (23) and PCB (32) models. The overall number of interactions understate the complexity of their interrelationships. Not all known (genetic predisposition, developmental stage, activity patterns, location) and unknown contributing factors were measured while other factors not in the model (acculturation, reproductive status

and marital status) were included. Ultimately, issues of data accessibility and availability will limit the extent to which this paradigm can be tested.

Models created for examining single chemical exposures may be inappropriate for evaluating multiple chemical exposures. There may be limits to which the modified environmental health paradigm can explain the phenomenon of exposure to multiple environmental chemicals. Best-fit logistic regression models for binary chemical combinations may yield discernable patterns with respect to the multiple chemical exposure model in this study. If they do not, it would imply a complexity that seems to increase exponentially with the addition of one more chemical. In the end, this paradigm may or may not have to be modified further or discarded all together.

Now that this study's findings have been revealed and discussed, the next chapter will summarize the study, draw its conclusions and outline its limitations before outlining its implications for theory development, research, education, policy and practice.

CHAPTER 5

SUMMARY, CONCLUSIONS, LIMITATIONS AND IMPLICATIONS

In this chapter, the study is summarized, conclusions are drawn and limitations are outlined. This is followed by implications of the study for theory development, research, education, practice and policy.

Summary

Lead, methylmercury and polychlorinated biphenyls (PCBs) are pervasive, persistent and co-occur in the environment. Each of these environmental chemicals are known to have neurobehavioral and neurodevelopmental consequences in animal models and human population studies. Since these neurotoxins bioaccumulate, the body burden from past exposures as well as maternal exposures during gestation transfer from mother to fetus via the placenta and to an infant and young child through lactation. Despite what is known about the hazards of exposures to these specific environmental chemicals, little is known about exposures to combinations of these chemicals. The purpose of this study was to address this research gap. This secondary analysis established the prevalence of four combinations and permutations of these chemicals in a large national probability sample of childbearing-aged women living in the United States 1999to 2004.

Exposure was defined as "the contact between an agent and a target with contact taking place at an exposure surface over an exposure period by an exposure route" (International Programme on Chemical Safety, 2000, p. 21). Six exposure-related

concepts were identified and defined: agent, environment, target (human), dose, health and vulnerability. The conceptual framework was Sexton, Olden and Johnson's modified environmental health paradigm (1993a).

This descriptive and exploratory study, existing data were analyzed from the National Health and Nutrition Examination Survey (NHANES), a national probability sample. The outcome of interest was based on evidence of biological uptake of two or more of the following: lead, methylmercury and the summed value of four lipid-adjusted polychlorinated biphenyl congeners (118, 138/158, 153 and 180) as measured by the presence of these xenobiotics at or above the geometric mean in the blood or serum of childbearing-aged females aged 16 to 49 of diverse races and ethnicities who were living in the U.S. from 1999 to 2004. The final cohort for this study consisted of 3,173 women including a subset of 391 who were pregnant. When adjusted (weighted) to the U.S. population, these participants represented 134.5 million childbearing-aged females of whom 4.8 million were pregnant. There were 62 measures of vulnerability (susceptibility- and exposure-related attributes, socioeconomic factors and race-ethnicity).

Data analysis encompassed concatenating and organizing the dataset, operationalizing dependent and independent variables and constructing software instructions. Descriptive and univariate statistics were used to estimate prevalence of exposure to each of the environmental chemicals of interest. Bivariate analyses (χ^2) identified the most common combinations and permutations of exposures. Best-fit logistic regression models were developed and analyzed. Tests for collinearity among independent variables were negative. All statistically-significant two-way interactions

among the independent variables were identified by comparing nested models using likelihood ratio testing. The data analysis concluded with calculating estimates of risk. The three research questions and major findings related to each one are summarized below.

1. What was the prevalence of childbearing-aged and pregnant childbearing-aged women's exposures to each of the following environmental chemicals: lead, methylmercury and polychlorinated biphenyls (PCBs) as measured by chemical-specific (xenobiotic) levels at or above geometric mean in blood or serum of these women who were living in the United States from 1999 through 2004?

Among childbearing-aged females, the prevalence rates for xenobiotic blood or serum levels at or above the geometric mean were 49 per 100 for lead, 48 per 100 for methymercury, and 67 per 100for PCBs. The number of childbearing-aged females above the 99th percentile was approximately 3 million, 2 million and 1.8 million for lead, methylmercury and PCBs, respectively. Women who were pregnant had lower prevalence rates.

2. What combinations and permutations of chemical exposures were most common among these childbearing-aged and pregnant childbearing-aged women as evidenced by xenobiotic blood levels at or above the geometric mean?

One fifth of childbearing-aged females had xenobiotic blood levels at or above the geometric mean for all three chemicals. The binary chemical combination of PCBs and lead was identified in 17% of childbearing-aged women who had two xenobiotic levels at or above the geometric mean while methylmercury and PCBs was identified in 27% of those who were pregnant.

3. What, if any, subsets of childbearing-aged women were disproportionately exposed to two or more of these environmental chemicals based on susceptibility-related attributes (reproductive status, age, health and nutritional status), exposure-related attributes related to acculturation, proximity (residential characteristics and occupation), activity (diet and tap water supply) and behavior (alcohol consumption and tobacco use); socioeconomic factors (education, employment, income and marital status) and race-ethnicity?

The best fit logistic regression exposure model included 13 independent variables: any fish consumption in the past 30 days, age, food security, ever breastfed, highest education level attained, any shellfish consumption in the past 30 days, marital status, selenium intake/RDA, time in longest employment, alcohol consumption, household size, serum cotinine and race-ethnicity.

Conclusions

Exposures to lead, methylmercury and PCBs were widespread among childbearing-aged and pregnant childbearing-aged women. Prevalence rates and distributions above the 99th percentile suggested a more widespread environmental exposure to PCBs among childbearing-aged and pregnant childbearing-aged women but disproportionately higher exposures to lead and methylmercury among subgroups of the study population. Women who were pregnant had lower prevalence rates. Lead and PCBs and PCBs and methylmercury were identified as the most common binary combinations among childbearing-aged women and pregnant women, respectively.

There were three notable findings regarding risk factors for multiple chemical exposures. Any fish consumption in the past 30 days tripled the odds of two or more

xenobiotic blood levels at or above the geometric mean. The odds of having two or more xenobiotic blood levels at or above the geometric mean rose non-linearly with age; exponentially among those aged 40 to 49. Those women who were currently breastfeeding or had ever breastfed a child for more than one month were 44% less likely to have two or more xenobiotic levels at or above the geometric mean than those who had never breastfed.

There were no discernable patterns across models. There were two anomalies noted regarding the appearance of education and the omission of current pregnancy in the best-fit exposure model as compared to those best-fit models for each chemical.

Limitations

There were six major limitations to this study. Since all data were collected at a single point in time only associations could be made about the relationships between dependent and independent variables. This study examined three chemicals which represent only a fraction of all chemicals detectable in the environment. While independent variables were selected based on the theoretical framework and a review of the scientific literature, not all variables could be operationalized given the data that were available in NHANES. This study was unable to fully test Sexton, Olden and Johnson's modified environmental health paradigm (1993a). Not all known (genetic predisposition, developmental stage, activity patterns, and location) and unknown contributing factors were measured while new factors were included (acculturation, reproductive status and marital status). The best-fit logistic regression models did not include interactions because the data were too sparse to test for all interactions. While this study's findings can be generalized to the population of childbearing-aged women

who lived in the United States 1999 to 2004, no inferences should be made regarding individual exposures or exposures among other populations inside or outside the United States.

Implications for Theory Development

In this study, a newly-identified concept (exposure) was introduced to nursing within the client domain. A concept analysis (Thompson, 2006) revealed that exposure had not been defined explicitly in the nursing literature even though the term was used frequently and characterized in many different ways. A transdisciplinary perspective was used to define exposure as "the contact between an agent and a target with contact taking place at an exposure surface over an exposure period by an exposure route" (International Programme on Chemical Safety, 2000, p. 21). As it is currently defined here, use of this concept should be incorporated into other nursing-related research, regardless of specialty. In this way, its usefullness to nursing can be evaluated.

Additionally, exposure could be considered a central concept in the environmental domain. Exposure as currently defined is conceptually congruent with Kim's definition of environment: "a separate entity that exists external to a person or to humanity, conceived … as that containing many distinct elements" that is, spatial, temporal and qualitative (socio-cultural) (Kim ,2000, p. 166). All nursing specialties support the relevancy and inclusion of the environment in research, practice and policy.

Alignment of this concept with existing theories was critically examined. The original environmental health paradigm explained exposure adequately but did not

address vulnerability. The modified environmental health paradigm was particularly helpful in understanding the interrelationships of exposure and vulnerability. In turn, this research supported its use empirically. Therefore, further use of this modified paradigm is endorsed for other related research.

In this study, new variables (acculturation, marital status and reproductive status) were introduced to the paradigm. It is unclear whether acculturation should continue to be subsumed as an exposure-related attribute as it was in this study or integrated with race-ethnicity. The role of marital status as a socioeconomic factor remains unclear due to missing data. Reproductive status was particularly important with this study population. All of these variables should be explored further to determine whether they should remain in the model.

Implications for Research

There were a number of useful avenues identified for progressing research in environmental health regarding multiple chemical exposures, including other population subgroups, improving specific variable measurement and expanding public access to NHANES data.

The widespread prevalence of exposures to these chemicals clearly indicate that further research on exposures to multiple environmental chemicals is needed. In general, mechanistic studies on interactions of multiple chemical combinations using *in vitro* toxicity assays would improve understanding of toxicokinetics and toxicodynamics at the cellular level. The need for mechanistic studies of PCBs on lead and lead on PCBs is underscored by this study's finding that this particular binary chemical combination was prevalent in 17% of childbearing-aged women who had

two xenobiotic levels at or above the geometric mean. Whether these chemicals have the same or similar toxic action may be irrelevant if there is a cumulative impact on health. In an effort to further understand the origins of the risk factors that comprised the best-fit logistic regression exposure model, best-fit logistic regression models for binary combinations of these chemicals should be formulated using these same datasets. Then, variables could be examined for discernable patterns across all models. These comparisons could assist in illuminating whether binary chemical models are appropriate for evaluating multiple chemical exposures and/or confirm whether single chemical models used currently to evaluate binary chemical exposures are still appropriate. In anticipation of improving the models' goodness-of-fit, interactions among independent variables could be more fully described by adding to the dataset from NHANES survey years (2005 to 2010). Evaluating the impact of bioaccumulation from multiple environmental chemical exposures on health will require longitudinal prospective studies. Transgenerational consequences of exposures will require prospective studies spanning more than two generations. In the meantime, childbearing-aged and pregnant childbearing-aged women will continue to be exposed to these neurotoxins. The magnitude of harm is larger than once thought. The severity of harm for those most vulnerable is irreversible (Barker, 2004; Barker et al., 2002).

With this study's finding of an exponential relative risk for exposure among women aged 40 to 49, establishing the prevalence of exposures to these environmental chemicals among females older than 49 should be strongly considered. With this additional information, it may be possible to determine whether this risk is related to

historical emissions, bioaccumulation or both. There may be opportunities for collaboration with existing studies. For example, from 1999 to 2004, NHANES analyzed blood samples of women aged 49 to 69 for lead and PCBs but not total and inorganic mercury. These blood samples are still available. Supplemental research proposals could be submitted to existing studies such as the National Women's Health Initiative and others (Western New York, Mount Sinai, Yale, Campaign Against Cancer and Stroke and/or the Nurses' Health Study).

Some methodological challenges were encountered during operationalization of independent variables. In general, validation is needed in the use of the Charleson Comorbidity Index (Charlson et al., 1987) and Child-Turcotte-Pugh Score (Child & Turcotte, 1964; Pugh et al., 1973) as measures of co-morbidity in a non-institutionalized population. In addition, the following recommendations address the NHANES dataset specifically:

1. Release population density-related data for all survey participants with regard to U.S. Census Bureau designations for urban, suburban or rural residence;
2. Obtain more detailed occupationally-related hazards data;
3. Change measurement of physical activity in accordance with established national standards (Ainsworth et al., 2000; Haskell et al., 2007);
4. Calculate packyears, pipeyears, etc. for former as well as current tobacco users;
5. Reinstate the question regarding history of peptic ulcers and add a question regarding gastric esophageal reflux disease (GERD);

6. Unrestrict data on alcohol consumption and tobacco use among 16 to 19 year olds.

7. Since CDC's *Healthy People 2020* objective EH-20.12 designated PCB 153 and PCB 126 as representatives of the non-dioxin-like and dioxin-like PCBs, respectively (Centers for Disease Control and Prevention, 2010), PCB 126 should be included in future studies. A petition to NHANES would be required to obtain data for this PCB congener for 1999 to 2004.

Implications for Education

The findings of this study should be used to inform healthcare practitioners and occupational and environmental health and safety (OEHS) professionals of the widespread prevalence of childbearing-aged and pregnant childbearing-aged women's exposures to lead, methylmercury and PCBs from 1999 to 2004. Emphasis should be placed on the transgenerational consequences of bioaccumulation and maternal exposures during gestation and lactation. Of equal importance are the interrelationships of exposure and vulnerability and risk factors for multiple environmental chemical exposures illuminated by this study.

In general, one outcome of this study is recognition of the need for continuing education with regard to these and related subjects, particularly, but not exclusively, among those practitioners in the maternal and child health-related specialties. Another outcome would be a more formal integration of these subjects into undergraduate and graduate curricula. It is through these educational efforts that healthcare practitioners and OEHS professionals will begin to integrate this new knowledge into their clinical practice.

Implications for Practice

In this study, a multitude of factors that increased or decreased prevalence of exposures were evaluated. By doing so, this study has facilitated practice aimed at ameliorating and preventing adverse health outcomes. Efforts at the state and local levels should concentrate on identifying, mitigating and eradicating existing anthropogenic sources of lead, methylmercury and PCBs. *Think global, act local* (Dubos, 1977). These interventions should emphasize continuous improvement and incorporate management of change with the application of the ALARA principle (As Low As Reasonably Achievable) and the use of best available technology.

Risk-based communication should ensure that the results of this research are readily available and understandable especially to demographic groups who were disproportionately represented in at-risk categories in this study. These communications must be appropriate to the audience and adequately address four areas of concern:

1. What is known with what accuracy and with what confidence?
2. What is not known and why is there uncertainty?
3. What could be known if there were more time, money and talent?
4. What should be known in order to act in the face of uncertainty?

(National Research Council, 2006, p. 209).

Opportunities to conduct participatory-based research should be encouraged. The effectiveness of fish consumption advisories for childbearing-aged women and in particular those who are pregnant should be evaluated. As one of the public's most trusted disciplines, nursing is in a unique position to be most effective in addressing the public's concerns about their environmentally-related health.

In order to protect the public's health, it becomes clear that risk-based efforts are not enough. Precaution and proaction should be advocated. Precautionary-level interventions should be designed and implemented to prevent exposures to these chemicals. Over time, these efforts will most likely result in lower exposure levels with a goal of zero harm through a cleaner environment, safer workplaces and healthier homes.

Currently, the routine use of xenobiotic biomonitoring in clinical practice is discouraged. Traditionally, occupational and environmental regulations have relied on noninvasive area and/or personal monitoring to quantify chemical exposures with subsequent invasive biomonitoring only if the regulatory action level is exceeded. While the elegance of xenobiotic biomonitoring is that it confirms exposure to a specific chemical, the ugliness of it is that it does not identify exposure sources. Transgenerational consequences of maternal exposures and bioaccumulation compound this problem. Interpreting biomonitoring results represents the biggest challenge to practitioners: *What does it mean in terms of an individual's health?* This question is not addressed in population-based research such as this study. However, public health policy is being formulated around it.

For example, one of CDC's *Healthy People 2020* objectives is a 30% reduction in these xenobiotic blood levels(Centers for Disease Control and Prevention, 2010):

Lead: 2.94 µg/dl
Mercury: 1.26 µg/l (ages 1-5) and 3.22 µg/l (childbearing-aged women)
PCB 126: 48.09 pg/g of lipid (ages 12 and older)
PCB 153: 67.97 ng/g of lipid (ages 12 and older)

Implications for Policy

Public health policy has a regulatory and fiduciary obligation to address two questions: *Is it safe? Is it safe enough?*

Is it safe? In this study, one fifth of childbearing-aged women were exposed to lead, methylmercury and PCBs as evidenced by blood levels concurrently at or above the geometric mean. Current environmental health policy has not addressed adequately the potential health effects of exposures to multiple environmental chemicals. The demand for strong empirical justification has led to a regulatory process that responds only when a high certainty of severe harm exists, a casualty of the 1980 U.S. Supreme Court benzene decision (Appendix I. International Union, AFL-CIO, et al. v. Petroleum Institute 448 U.S. 607, 1980). As discussed previously, strong empirical evidence will take decades to assemble. Proposed legislation that is currently before the U.S. Senate Committee on Environment and Public Works would strengthen the effectiveness of U.S. EPA's 1976 Toxic Substances Control Act (TSCA). However, given the recent changes in House majority and opposition from business, the future of this pending legislation is uncertain. In the meantime, another generation is exposed. The proposed *Safe Chemicals Act* is based on six principles established by the U.S. Environmental Protection Agency (2010f):

1. Chemicals should be reviewed against safety standards that are based on sound science and reflect risk-based criteria protective of human health and the environment.
2. Manufacturers should provide EPA with the necessary information to conclude that new and existing chemicals are safe and do not endanger public health or the environment.
3. Risk management decisions should take into account sensitive subpopulations, cost, availability of substitutes and other relevant considerations.

4. Manufacturers and EPA should assess and act on priority chemicals, both existing and new in a timely manner.
5. Green chemistry should be encouraged and provisions assuring transparency and public access to information should be strengthened.
6. EPA should be given a sustained source of funding for implementation.

These principles bellweather two changes to current policy. One is the shift in the burden of proof from "innocent until proven guilty" to "guilty until proven innocent." The other requires risk assessments to address "sensitive subpopulations." It is uncertain whether this reference encompasses fetuses.

Is it safe enough? Should protecting the next generation by regulating environmental exposures of the current generation be addressed in public and environmental health policy? Should pregnant and lactating women be exclusively protected? These are complex issues with implications for healthcare practice and far-reaching impacts on corporate social responsibility and society as a whole. There are no guidelines for multiple chemical exposures among pregnant and lactating women. Until just recently, there were no guidelines for single chemical exposures among these women either. Clearly, this study suggests that guidelines are needed for both. Though this study did not focus on single chemical exposures, these recent guidelines do herald first steps into the quagmire of controversy. The possibilities for unintended consequences of its implementation are discussed here.

Recently, the National Center for Environmental Health (NCEH) published *Guidelines for the Identification and Management of Lead Exposure in Pregnant and Lactating Women* (2010). "These recommendations … should not significantly impact many individuals or clinical practices" (National Center for Environmental Health, 2010, p. iv). These guidelines do not recommend routine prenatal testing of

all women in the U.S. because it is estimated only one percent of the population would be impacted. This study estimated three million childbearing-aged and 433,000 pregnant childbearing-aged women had blood lead levels above the 99th percentile. These guidelines recommend client education as well as environmental, nutritional, and behavioral interventions beginning when a woman's prenatal blood lead level is 5 μg/dl and higher. Secondly, these NCEH guidelines encourage mothers in the U.S. to breastfeed as long as their blood lead levels are less than 40 μg/dl. It encourages those women with higher blood lead levels to pump and discard their breast milk until their blood lead levels are below 40 μg/dl. The reader is reminded that for every 10 μg/dl increase in blood lead level there is a corresponding five point decrease in the mean IQ scores in children (Needleman, 1989). This study has reported prevalence rates were lower for pregnant women than those of childbearing-aged women. Four possible explanations were offered as to why current pregnancy was protective for these women. As discussed previously, interpretation of biomonitoring results will be complicated by the physiological changes that occur during pregnancy and bioaccumulation from past exposures. Given this study's findings and the litigious society in which healthcare practices, the most prudent recommendation may be for clinical practitioners to routinely conduct lead biomonitoring with initial preconceptual or prenatal care which is followed by postnatal testing of lactating women. Limited access to healthcare for women at highest risk for exposure and the availability of qualified analytical laboratories and the cost will be significant barriers to implementation.

These guidelines recommend removing pregnant women from occupational lead exposures at blood lead levels 10 μg/dl and higher. Currently, medical surveillance guidelines in the U.S. Department of Labor, Occupational Safety and Health Administration's (OSHA) lead standard (29 Code of Federal Regulations §1910.1025, §1926.62) requires employers to implement a biomonitoring program only when the environmental lead level exceeds an eight-hour time-weighted average of 30μg/m^3 for more than 30 days per year. Subsequently, any worker with a blood lead level 40 μg/dl and higher is removed from the work area while being afforded job protection. OSHA allows an employee to return to work when two consecutive blood lead levels are below this threshold. The NCEH guidelines neither indicate at what blood lead level a pregnant woman should return to work nor clarify whether a blood lead level of 10 μg/dl and higher is de facto worker compensable. (It should be noted that this study found non-U.S. citizenship, older residential age and tobacco use were three of the statistically significant risk factors for a blood lead level at or above the geometric mean). Employers have a statutory obligation to provide a safe workplace for all workers. While a fetal protection policy is neither acceptable nor legal (Appendix J. International Union, United Automobile, Aerospace and Agricultural Implement Workers of American, UAW, et al. v. Johnson Controls, Inc. 499 U.S. 187, 1991), would employers be held liable for fetal injury? Clearly, these incongruences require further clarification. *So, why are we waiting nine months to find out about maternal and fetal exposures to environmental chemicals?* "The Precautionary Principle urges precaution when the magnitude of the potential adverse event is large

or the adverse outcome is severe, even if its probability is small" (Ricci et al., 2003, p. 3).

Exposures to environmental chemicals in the United States impact society as a whole. In a 1989 commentary on lead poisoning, Dr. Herbert L. Needleman discussed a study which found a difference in mean IQ scores between children exposed to lead and those who were not exposed. He wrote:

> This four-to-seven point difference in means has been taken by some as a small effect. This is deceptive. The cumulative frequency distribution for IQ, typical for many distributions is sigmoid. When cumulative distributions between groups are plotted and compared, a shift in the curve resulting in a difference in medians of six points results in a four-fold increase in the rate of severe deficit (IQ < 80). This same shift in distribution truncates the upper end of the curve, where superior function is displaced by 16 points. This means that five percent of lead-exposed children are prevented from achieving truly superior function (IQ > 125). The costs of this effect at the high end of the distribution have received no attention; they may be extraordinarily important to our society (p. 643).

Just think how smart we all could have been.

APPENDIX A

ACRONYMS

AAOHN	Association of American Occupational Health Nurses
ABLES	Adult Blood Lead Epidemiology and Surveillance
ALARA	as low as reasonably achievable
AMDR	acceptable macronutrient distribution range
ANOVA	analysis of variance
APHA	American Public Health Association
ASSE	American Society of Safety Engineers
ATSDR	Agency for Toxic Substances and Disease Registry
BINWOE	binary weight of evidence
BMI	body mass index
χ^2	chi -square
CCMI	Charlson Co-Morbidity Index
CD4	cluster of differentiation 4 cells
CDC	Centers for Disease Control and Prevention
CFSM	Core Food Security Measure
CI	confidence intervals
CINAHL	Cumulative Index to Nursing and Allied Health Literature
DNA	deoxyribonucleic acid
EHS	environmental health and safety
EIA	enzyme immunoassay
EPA	Environmental Protection Agency
ET-AAS	electrothermal atomic absorption spectrometry
ETS	environmental tobacco smoke
fL	femtoliters (a measurement of volume)
FSSM	Food Security and Hunger Survey Module
FWA	Federal Wide Assurance
GAO	Governmental Accounting Office
GB	gigabyte
GED	general educational development
Hg^0	elemental mercury
HHANES	Hispanic Health and Nutrition Examination Survey
HIV	Human Immunodeficiency Virus
HRGC/HRMS	high resolution gas chromatography/high resolution mass spectrometry
ICP/DRC-MS	inductively-coupled plasma dynamic reaction cell-mass spectrometry
ICP-MS	inductively-coupled plasma-mass spectrometry

ID HPLC-APCI MS/MS	isotope dilution high performance liquid chromatography – atmospheric pressure chemical ionization tandem mass spectrometry
IHg	inorganic mercury
IPCS	International Programme on Chemical Safety
IQ	Intelligence Quotient
IRB	Institutional Review Board
IUPAC	International Union of Pure and Applied Chemistry
kg/m^2	kilograms per squared meter
LoD	level of detection
µg/dl	micrograms per deciliter
µg/L	micrograms per liter
mg/dl	milligrams per deciliter
mg/kg	milligrams per kilogram
mg/m^3	milligrams per cubic meter
MEC	Medical Examination Center
MeHg	methylmercury
mRNA	messenger ribonucleic acid
ng/dl	nanograms per deciliter
ng/g	nanograms per gram
ng/ml	nanograms per millilter
NCEH	National Center for Environmental Health
NCHS	National Center for Health Statistics
NHANES	National Health and Nutrition Examination Survey
NHES	National Health Examination Survey
NIEHS	National Institute of Environmental Health Sciences
NMDA	n-methyl-D-aspartic acid
OEHS	Occupational and Environmental Health and Safety
OR	odds ratio
OSHA	Occupational Safety and Health Administration
oz.	ounce
pg/g	picograms per gram
p value	probability of rejecting the null hypothesis when it is actually true
Pb	lead
PC12	a cell line derived from a pheochromocytoma cell of rat adrenal medulla
PCBs	polychlorinated biphenyls
PHI	protected health information
ppm	parts per million
PRAMS	Pregnancy Risk Assessment Monitoring System
PUBMED	Publication Service of U.S. National Library of Medicine
r^2	goodness-of-fit statistic
RDA	recommended dietary allowance
RNA	ribonucleic acid

RR	relative risk
SD	standard deviation
SELDI-TOF MS	surface-enhanced laser desorption/ionization-time-of-flight mass spectrometry
TIBC	total iron binding capacity
TSCA	Toxic Substances Control Act
TSDF	transfer, storage and disposal facility
VIF	variance inflation factor
WIC	Special Supplemental Nutrition Program for Women, Infants and Children

APPENDIX B

HAZARD CATEGORIES

Chemical Hazards
- Health-Related Chemical Hazards (corrosive, irritant, sensitizer, toxic, carcinogen, reproductive, asphyxiates)
- Physical-Related Chemical Hazards (flammable, combustible, reactive, oxidizer, compressed gas, cryogen)
- Nanotechnology

Physical Hazards
- Energy/Electro-Magnetic Fields/Electricity
- Ionizing Radiation (x-rays, gamma rays)
- Non-Ionizing Radiation (ultraviolet, laser, infrared, radio frequencies, sound/noise)
- Temperature (heat/cold)
- Pressure
- Climatological

Mechanical Hazards
- Mechanical Energy
- Vibration
- Ergonomically-Related Hazards (posture, position, pressure, repetitive motion)
- Manual Materials Handling
- Impact (slip, trip and fall hazards, trauma)
- Confined Spaces

Biological Hazards
- Allergens, bacteria, endotoxins, envenomations, fungi/mold, malignant cells, microbacteria, parasites, recombinants, rickettsiae, viruses, wood dust

Psychosocial Hazards
- Stress and Strain (emotional strain, interpersonal strain, lateral violence, work-family conflict)
- Fatigue (shift work)
- Organizational Culture
- Violence/Terrorism

Appendix B. Hazard Categories. Adapted from "Scientific Foundations of Occupational and Environmental Health Nursing Practice" by J. Agnew, 2001. In M. K. Salazar (Ed.), *Core Curriculum for Occupational & Environmental Health Nursing* (2nd ed., pp. 111-145). Copyright 2001 by W. B. Saunders Company.

APPENDIX C

CONCEPTUAL DEFINITIONS

Environment

A separate entity that exists external to a person or to humanity … as that containing many distinct elements: spatial, temporal and qualitative (Kim, 2000, p. 167)

Exposure Pathway. The course an agent takes from its source to the target (International Programme on Chemical Safety, 2000, p. 24; Zartarian, Ott, & Duan, 2007, p. 58)

Transport. Carrier medium for an agent: air, water, soil, dust, food, product or item (International Programme on Chemical Safety, 2000, p. 22)

Medium. Material surrounding or containing an agent: air, water, soil, food, product or item (Zartarian, Bahadori, & McKone, 2005, p. 4)

Micro-Environment. Surroundings that can be treated as homogeneous or well-characterized in regard to the concentration of an agent (Zartarian, Bahadori, & McKone, 2005, p. 4)

Accumulation in Environment. Refers to agents with extended biogeochemical cycles; persistence; environmental factors that facilitate accumulation: air and sea temperatures, wind speed, variation in precipitation (Lindberg et al., 2007) or soil acidification (Navratil, Skrivan, Vach, Dobesova, & Langrova, 2004)

Transformation. Conversion of agent into one or more resultant products by biotic or abiotic processes such as hydrolysis, oxidation-reduction; dependent upon physical and chemical properties of agent and medium (Yong, 2001, p. 208)

Agent

A chemical, biological or physical entity that contacts a target (Zartarian, Ott, & Duan, 2007, p. 58); a/k/a hazard, stressor

Hazard. Agent or environment capable of causing harm. There are five general types of hazards: chemical, physical, mechanical, biological and psychosocial (Agnew, 2001, p. 111); a threat comprised of perturbations, stress/stressors and the consequences they produce (Turner et al., 2003a, p. 8074)

Stressor. Any entity, stimulus or condition that modulates normal functions of an organism (target) or induces an adverse response (Zartarian, Ott, & Duan, 2007, p. 59); a source of continuous or slowly increasing stress; commonly found within the range of normal variability (Turner et al., 2003a, p. 8074)

Perturbation. Beyond the normal range of variability in which the system operates (Turner et al., 2003a, p. 8074)

Source a/k/a Emission Source. The origin of an agent: anthropogenic (man-made) or non-anthropogenic (exists in nature); area or point; stationary or mobile; indoor or outdoor; occupational or residential or community; site- or source-specific; geographic in scope (i.e., local, regional, national, international, global) (International Programme on Chemical Safety, 2000, p. 23)

Concentration (of agent). The amount of matter-form agent per unit volume for example, mg/kg (food), mg/liter (water), $\mu g/cm^2$ (surface), % by weight, $\mu g/m^3$ (air),

fibers/ m^3 (air), parts per million or ppm (air); a/k/a media concentration (International Programme on Chemical Safety, 2000, p. 22; Zartarian, Ott, & Duan, 2007, p. 57)

Properties. Physical state and chemical behavior of agent that directly affects rate and extent of dose and distribution in the environment and target: energy or matter; gas or vapor; molecular size; pH (acidity or alkalinity); hydro- or lipid-solubility; (Zartarian, Ott, & Duan, 2007, p. 39)

Intake Fraction. Incremental intake of a pollutant summed over all exposed individuals and occurring over a given exposure time released from a specified source or source class, per unit of pollutant emitted (Bennett et al., 2002, p. 2)

Mixture. Any combination of two or more agents regardless of source or of spatial or temporal proximity (Agency for Toxic Substances and Disease Registry, 2001, p. 3)

Similar Mixture. Agents with comparable properties that is, chemical structure, toxicological mechanism or common mode of toxicity (Sexton et al. 1995c; Sexton & Hattis, 2007, p. 825)

Defined Mixture. Agents possessing reasonably defined composition but not necessarily possess similar properties when emitted at a given time and place (Sexton et al., 1995c; Sexton & Hattis, 2007, p. 825)

Coincidental Mixture. Agents present at a common time or place of interest but not necessarily possess similar properties or composition (Sexton et al., 1995c; Sexton & Hattis, 2007, p. 825)

Exposure

Contact between an agent and a target with contact taking place at an exposure surface over an exposure period by an exposure route (International Programme on Chemical Safety, 2000, p. 21)

Exposure Surface. A surface on a target where an agent is present a/k/a contact boundary or contact surface (Zartarian, Ott, & Duan, 2007, p. 57)

Exposure Period. The time of continuous contact between an agent and a target (Zartarian, Ott, & Duan, 2007, p. 58)

Exposure Frequency. The number of exposure events in an exposure duration (Zartarian, Ott, & Duan, 2007, p. 58)

Exposure Duration. Cumulative length of time over which continuous or intermittent contact occurs between an agent and a target (International Programme on Chemical Safety, 2000, p. 22; Zartarian, Ott, & Duan, 2007, p. 58)

Exposure Route. The way an agent enters a target after contact: inhalation, ingestion, dermal absorption, injection; a/k/a/ route of entry (International Programme on Chemical Safety, 2000, p. 22; Zartarian, Bahadori, & McKone, 2005, p. 3)

Exposure Concentration. Concentration of an agent at the point of contact with the outer boundary of the target (International Programme on Chemical Safety, 2000, p. 26)

Absorption Barrier. A contact boundary or exposure surface that allow differential diffusion of an agent into a target: skin, respiratory tract lining, gastrointestinal tract wall (International Programme on Chemical Safety, 2001b, p. 3; Zartarian, Bahadori, & McKone, 2005, p. 2)

Exposure-Related Terms

Target. A biological entity, physical or ecological object exposed (or potentially exposed) to an agent that is, human or non-human, population, subpopulation, organ system, subsystem or system component (Zartarian, Bahadori, & McKone, 2005, p. 4); an entity capable of compensatory response and adaptation (Dubos, 1980, p. 22); a/k/a organism

Dose. The amount of agent that enters a target in a specified time duration after crossing an exposure surface or absorption barrier a/k/a internal dose, absorbed dose (International Programme on Chemical Safety, 2000, p. 27)

Intake. The process by which an agent crosses an outer exposure surface of a target without passing an absorption barrier (Zartarian, Ott, & Duan, 2007, p. 58)

Intake Dose. Dose resulting when an agent crosses an outer exposure surface of a target without passing an absorption barrier (Zartarian, Ott, & Duan, 2007, p. 58)

Uptake. The process by which an agent crosses an absorption barrier (Zartarian, Ott, & Duan, 2007, p. 59)

Uptake Dose. Dose that results from an agent crossing an absorption barrier (Zartarian, Ott, & Duan, 2007, p. 58)

Bioavailability. The rate and extent to which an agent can be absorbed by a target and is available for metabolism or interaction with biologically significant receptors; a/k/a internal dose (International Programme on Chemical Safety, 2000, p.26)

Toxicokinetics. Modeling and mathematical description of the time course of disposition of xenobiotics in the whole organism (Medinsky & Valentine, 2003, p. 98). "What does the target do to the agent?" (Rozman, Doull, & Hayes, 2001, p. 3)

Distribution. Distribution of agent among target's anatomical or physiologic compartments via systemic circulation (blood and/or lymph) resulting in different concentrations in various compartments (tissues and/or organs) over time; distribution rate depends initially upon absorption rate of agent by target (Gregus & Klaassen, 2003, p. 23)

Mechanisms Facilitating Distribution. Porosity of the capillary endothelium, specialized transportation across the plasma membrane, accumulation in cell organelles, reversible intracellular binding (Gregus & Klaassen, 2003, p. 24)

Mechanisms Opposing Distribution. Binding to plasma proteins, specialized barriers, distribution to storage sites, association with intracellular binding proteins, exportation from cells (Gregus & Klaassen, 2003, p. 24)

Bioaccumulation. Accumulation of agent and/or its metabolites in the target via storage and/or re-absorption (Eaton, 2005, p. 98)

Storage. Accumulation of agent in one or more of the target's tissues (Dix, 2001, p. 568)

Re-absorption. Agent diffuses back across cellular membrane and re-enters distribution system. Increases half-life. Dependent upon lipid solubility of agent. Inversely related to degree of ionization (Gregus & Klaassen, 2003, p. 25)

Elimination. Chemical and physical mechanisms by which a target first detoxifies then excretes an agent (Gregus & Klaassen, 2003, p. 24)

Biotransformation. Biochemical mechanism employed by target to breakdown the agent; enzymatic pathways. Metabolic activation or detoxification reactions that increase hydrophilicity and promote excretion by changing an agent into its metabolite which may be more or less toxic to target (Eaton, 2005, p. 99)

Excretion. Physical mechanism by which target returns agent to the environment: urine, bile/feces, exhaled breath, sweat, hair (Gregus & Klaassen, 2003, p. 24)

Toxicodynamics. Modeling and mathematical description of the time course of disposition of xenobiotics in the whole organism (Medinsky & Valentine, 2003, p. 98). "What does the agent do to the target?" (Rozman, Doull, & Hayes, 2001, p. 3)

Biologically-Effective Dose. That portion of the dose that reaches the target site of (toxic) action; a/k/a delivered dose (International Programme on Chemical Safety, 2000, p. 27)

Target Site. Endogenous molecule, cell, tissue, organ and/or whole organism for which an agent has an affinity based on its chemical reactivity properties (Gregus & Klaassen, 2003, p. 27); site at which an agent alters cell function, regulation and/or maintenance

Biological Effect. A measurable response to dose in a molecule, cell or tissue; a functional compensatory change in morphology, physiology, growth, development and/or life span of the target as a result of stressor or other environmental influences (International Programme on Chemical Safety, 2000, p. 27)

Body Burden. The amount of agent in the body at a given instant in time (Zartarian, Ott, & Duan, 2007, p. 57)

Half-Life. Amount of time required for a given chemical concentration in target's blood or plasma to decrease by 50% (Medinsky & Valentine, 2003, p. 101)

Steady-State. A dynamic equilibrium or concentration constant when dose and exposure frequencies remain constant (adapted from Dix, 2001, p. 570)

Dose-Response Relationship. A relationship in which a change in the amount, intensity or duration of exposure is associated with a change (increase or decrease) in risk of a specified outcome (adapted from International Programme on Chemical Safety, 2001b, p. 15); cause-and-effect relationship that is precise and measurable (Eaton & Klaassen, 2003, p. 16)

Hormesis. Phenomenon where a modest stimulation of response occurs at low doses and an inhibition of response occurs at high ones; graphically depicted as an inverted *u*-shaped or *j*-shaped dose response curve; the shape difference being dependent upon the endpoint measured that is, growth or survival versus disease incidence, respectively (Calabrese & Baldwin, 2003)

Dose Threshold. A minimally-effective dose of an agent below which the probability of a target's response is zero (Rozman, Doull, & Hayes, 2001, p. 10)

Independence. Dose or effect is unaffected by the presence of another component dose or effect (Sexton & Hattis, 2007, p. 828)

Antagonism. Dose or effect is less-than-additive than the sum of individual component doses or effects (Sexton et al., 1995c, p. 436)

Additivity. Dose or effect is equivalent to the sum of individual component doses or effects, respectively (Sexton et al., 1995c, p. 436)

Inhibition. One component decreases the effect of another without having an effect itself (Agency for Toxic Substances and Disease Registry, 2001, p. 4)

Potentiation. One component increases the effect of another without having an effect itself (Agency for Toxic Substances and Disease Registry, 2001, p. 4)

Synergism. Dose or effect is greater than the sum of individual component doses or effects (Sexton et al., 1995c, p. 436)

Health

Functional compensatory capacity for stress/stressors and other environmental influences (adapted from the definition of adverse biological effect, International Programme on Chemical Safety, 2000, p. 27); an expression of the success experienced by the organism in its effort to respond adaptively to environmental challenges (Dubos, 1980, p. xvii); on a continuous scale of well-being (Linder, 1958, p. 1276)

Morbidity. Illness (manifest and non-manifest), injuries and impairments (Linder, 1958, p. 1276)

Disease. Expression of failure in an effort to respond adaptively to environmental challenges (Dubos, 1980, p. xvii)

Toxicity. The accumulation of injury over short or long periods of time which renders an organism incapable of functioning within the limits of adaptation or other forms of recovery (Rozman, Doull, & Hayes, 2001, p. 1)

Biomarker

Biochemical, molecular, genetic, immunologic or physiologic indicator of a recent or previous event in biological systems (National Research Council, 2006, p. 21)

Biomarker of Exposure. An agent, its metabolite or product of an interaction between an agent and a target molecule or cell that is measured in a compartment in a target (National Research Council, 2006, p. 21)

Metabolite. Chemical alteration of the agent produced by target's body tissue (National Research Council, 2006, p. 15)

Xenobiotic. An agent's parent compound(s) measured as a concentration per specific target medium (Wallace, 2007, p. 395)

Biomarker of Effect. A biochemical, molecular, genetic, immunologic or physiologic indicator of effect from exposure/dose (National Research Council, 2006, p. 21)

Biomarker of Susceptibility. Used to identify either individuals or populations who might have a different risk based upon differences that are inherent or acquired; this inherent category includes genetic polymorphisms (National Research Council, 2006, p. 22)

Genetic Polymorphism. Presence of a genetic abnormality, specifically two or more alleles in the DNA sequence of a particular gene, with a frequency of occurrence greater than or equal to one percent (National Research Council, 2000a, p. 90)

Vulnerability

Susceptibility to harm; the degree to which a system, subsystem or system component is likely to experience harm due to exposure to a hazard (Turner et al., 2003a, p. 8074)

Susceptibility. The combination of intrinsic and acquired attributes that alter biological response to environmental insult (Sexton, 1997, p. 264)

Health Disparity. Higher relative risk; increased comparative morbidity, premature mortality and/or diminished quality of life (adapted from Flaskerud & Winslow, 1998, p. 69)

Risk

The probability that an event will occur over some period of time (Johnson, 2007, p. 416)

Risk Assessment. Hazard identification, dose-response assessment, exposure assessment, risk characterization (U.S. Environmental Protection Agency, 2010c)

***Hazard Identification*.** The process of identifying and determining agent, exposure and outcome. "Does the agent cause the adverse effect?" (U.S. Environmental Protection Agency, 2010c)

***Dose-Response Assessment*.** Describes the quantitative relationship among agent, exposure and outcome. "What is the relationship between dose and incidence in humans?" (U.S. Environmental Protection Agency, 2010c)

***Exposure Assessment*.** The estimation or measurement of the magnitude, duration, timing and route of exposure. "What exposures are currently experienced or

anticipated under different conditions?" (U.S. Environmental Protection Agency, 2010c)

Risk Characterization. Combines information from the other elements to estimate the level of response for the identified outcome at the specific level of exposure to the agent in a defined population. "What is the estimated incidence of the adverse effect in a given population?" (U.S. Environmental Protection Agency, 2010c)

Environmental Justice. The fair treatment and meaningful involvement of all people regardless of race, color, national origin or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies (U.S. Environmental Protection Agency, 2010d)

Fair Treatment. No group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal and commercial operations or the execution of federal, state, local, and tribal environmental programs and policies (U.S. Environmental Protection Agency, 2010d)

Meaningful Involvement. Potentially affected community residents have an appropriate opportunity to participate in decisions about a proposed activity that will affect their environment and/or health. There are three outcomes to a meaningful involvement: 1. the public's contribution can influence the regulatory agency's decision; 2. the concerns of all participants involved will be considered in the decision-making process; and 3. the decision-makers seek out and facilitate the involvement of those potentially affected (U.S. Environmental Protection Agency, 2010d)

Precautionary Principle

"When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. The Principle includes taking action in the face of uncertainty; shifting burdens of proof to those who create risks; analysis of alternatives to potentially harmful activities; and participatory decision-making methods. The precautionary principle takes the life cycle of products or chemicals into account and adds the proactive step of pre-market analysis of environmental harm" (American Nurses Association, 2003).

Major Concepts of the Precautionary Principle.

Sustainability. Conduct environmental health work in such as way that it allows future generations to meet their health needs as well;

Healthfulness. The health of humans and the environment needs to be restored, balanced, and harmonized;

Ecological Health. Field of inquiry and action to reconcile the care and health of ecosystems, populations, communities and individuals;

Interconnection. Environmental health actions have far-reaching consequences;

Respect for All Life. Environmental health work should be conducted with respect for both human and non-human life;

Global Equity. Everyone is entitled to just and equal access to the basic resources needed for an adequate and healthy life;

Respectful Participation. Respect the considered and responsible choices of stakeholders, whether individuals or organizations; and

Realistic Understanding. Environmental health ethics should be founded on a realistic understanding of the health sciences and the risks and benefits of proposed activities and investments.(Adapted from Jameton, 2005)

APPENDIX D

ASSESSING CHEMICAL INTERACTIONS

Classification for Understanding the Mechanisms of Interaction		**Weighting**
I.	well characterized mechanisms and unambiguous interpretation of the direction of interaction	1.00
II.	structure/activity relationships infer likely mechanisms and direction of interaction	0.79
III.	information on mechanisms inadequate or ambiguous with direction of interaction unclear	0.32

Classification of Toxicological Significance of the Interaction		**Weighting**
A.	directly demonstrated	1.00
B.	inferred or demonstrated in related compounds	0.79
C.	unclear	0.32

Modifiers		**Weighting**
1.	anticipated exposure duration and sequence	1.00
2.	different exposure duration and sequence	0.79
a.	*in vivo* data	1.00
b.	*in vitro* data	0.79
i.	anticipated route of exposure	1.00
ii.	different route of exposure	0.79

Weighting Factor = Product of Weighting Scores	**0.05 - 1.00**

Direction of Interaction		Direction
>	Greater-Than-Additive	+1
=	Additive	0
<	Less-Than-Additive	-1
?	Indeterminate	0

BINWOE = (Weighting Factor)(Direction Factor) = -1 through 0 to +1

Appendix D. Assessing Chemical Interactions. Adapted from *Guidance Manual for the Assessment of Joint Toxic Action of Chemical Mixtures* by the Agency for Toxic Substances and Disease Registry, 2001, p. B-4. Copyright 2001 Author.

APPENDIX E

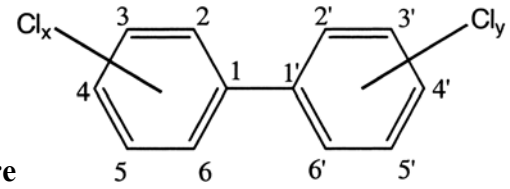
HISTORY OF NHANES

YEAR	DESCRIPTION
1949	U.S. National Committee on Vital and Health Statistics
1951	Subcommittee on National Morbidity Surveys Report
1953	Proposal for Collection of Data on Illness and Impairment
1956	National Health Survey Act (Public Law 652)
	National Center for Health Statistics (NCHS)
1956-1960	Public Health Services Report to Surgeon General
	Public Health Conference on Records and Statistics
1960-1962	First National Health Examination Survey NHES I
1963-1965	NHES II
1966-1970	NHES III
1969	White House Task Force Report on Nutrition
1971-1975	National Health and Nutrition Examination Survey
	NHANES I
1976-1980	NHANES II
1982-1984	Hispanic HANES
1988-1994	NHANES III
1999-present	Continuous NHANES

Appendix E. History of NHANES. Adapted from *Survey Overview and History* by the Centers for Disease Control and Prevention, National Center for Health Statistics, 2009h. Copyright 2009 Author.

APPENDIX F

POLYCHLORINATED BIPHENYL TERMINOLOGY



Basic PCB Molecular Structure

Congener. 209 different configurations of the basic PCB molecular structure having one to ten chlorine atoms attached to the biphenyl molecule

Homolog. PCB molecules having the same number of chlorine atoms

Isomers. Homologs with different chlorine substitution patterns

Substitution. Chlorine atom replaces hydrogen atom in the biphenyl molecule

Ortho-Substituted Positions: 2, 2′, 6, 6′

Meta-Substituted Positions: 3, 3′, 5, 5′

Para-Substituted Positions: 4, 4′

Planar or Coplanar. Two benzene rings lie in the same plane

Non-Planar or Non-Coplanar. Two benzene rings lie perpendicular to each other; degree of planarity determined by number of *ortho*-substitutions

IUPAC Number. Nomenclature assigned to a specific PCB congener for ease of reference

Dioxin-Like PCBs.

PCB 118: 2,3′,4,4′5-Pentachlorobiphenyl (mono-*ortho*-substituted planar)

Non-Dioxin PCBs.

PCB 138: 2,2′,3,4,4′,5′-Hexachlorobiphenyl (*ortho*-substituted non-planar)

PCB 153: 2,2′,4,4′,5,5′-Hexachlorobiphenyl (*ortho*-substituted non-planar)

PCB 180: 2,2′,3,4,4′,5,5′-Heptachlorobiphenyl (di-*ortho*-substituted planar)

Appendix F. Polychlorinated Biphenyl Terminology. Adapted from "Effects of polychlorinated biphenyls on the nervous system," by O. Faroon, D. Jones, and C. de Rosa, 2000, *Toxicology and Industrial Health, 16*, p. 308. Copyright Arnold, 2000.

APPENDIX G

UNIVERSITY OF RHODE ISLAND

INSTITUTIONAL REVIEW BOARD ON HUMAN SUBJECTS

IRB ACTION REPORT

The University of Rhode Island
INSTITUTIONAL REVIEW BOARD ON HUMAN SUBJECTS (IRB)
IRB ACTION REPORT

The activity indicated below has been reviewed by the University of Rhode Island Institutional Review Board (IRB) in accordance with the requirements of Title 45, Part 46 of the Code of Federal Regulations (Protection of Human Subjects), or other federal regulations as required such as 21CFR 50. The University has an approved assurance of compliance on file with the Department of Health and Human Services which covers this activity. Our assurance number is FWA 00003132. Any changes which may alter the investigational situation must be reported promptly to the IRB. Any questions concerning this action can be directed to the Office of Research Compliance at:

The Office of Research Compliance, 70 Lower College Road
University of Rhode Island, Kingston, RI 02881
telephone: (401) 874-4328
robind@uri.edu

Mailed to: IRB ID No. HU0910-084

Faculty Investigator or Sponsor:	Student Investigator or Co-PI:
Donna Schwartz Barcott Nursing White Hall	Marcella Remer Thompson 355 Grandview Road East Greenwich, RI 02818

Project Title: "Exposures to Multiple Environmental Chemicals (Lead, Methylmercury, Polychlorinated Biphensls) Among Childbearing-Aged Women in the U.S."

Date of Initial IRB Review:	Initial Review:	Date of Action:	Action:	Monitoring Interval:
12/30/2009	Category: Exempt not human subject	12/30/2009	Reviewed	duration of project
Date of InitialApproval :		*Once approved, you may not use more than ? subjects		

Waiver of elements of Informed Consent : FDA regulated study?

The IRB chair has deemed this to be not human subjects research.

IRB Chair (or Designated Member) 1/2/10 Date

Doreen B. Lawson Director of Compliance 1/5/10 Date

APPENDIX H

RHODE ISLAND DEPARTMENT OF HEALTH

INDIVIDUAL INVESTIGATOR AGREEMENT

Version Date: 1/6/2005

(9) The Investigator acknowledges and agrees to cooperate in the IRB/IEC's responsibility for initial and continuing review, record keeping, reporting, and certification for the research referenced above. The Investigator will provide all information requested by the IRB/IEC in a timely fashion.

(10) The Investigator will not enroll subjects in research under this Agreement prior to its review and approval by the IRB/IEC.

(11) Emergency medical care may be delivered without IRB/IEC review and approval to the extent permitted under applicable federal regulations and state law.

(12) This Agreement does not preclude the Investigator from taking part in research not covered by this Agreement.

(13) The Investigator acknowledges that he/she is primarily responsible for safeguarding the rights and welfare of each research subject, and that the subject's rights and welfare must take precedence over the goals and requirements of the research.

Co-Investigator Signature: _____ Date: 11/11/09

Name: Vanderslice (*Last*) Robert (*First*) R. (*Middle Initial*) Degree(s): PhD

Address: RI Department of Health 3 Capitol Hill Phone #: 401-222-7766

Providence (*City*) RI (*State/Province*) 02908-5097 (*Zip/Country*)

FWA Institutional Official (or Designee): _____ Date: 11/17/09

Name: FULTON (*Last*) JOHN (*First*) P. (*Middle Initial*) Institutional Title: IRB CHAIR

Address: RHODE ISLAND DEPARTMENT OF HEALTH. 3 CAPITOL HILL Phone #: 401-641-8806

PROVIDENCE (*City*) RI (*State/Province*) 02908-5097 (*Zip/Country*)

APPENDIX I

INDUSTRIAL UNION DEPT. v. AMERICAN PETROL. INST., 448 U.S. 607 (1980)

Industrial Union Department, AFL-CIO v. American Petroleum Institute, et al. Certiorari to the United States Court of Appeals for the Fifth Circuit No. 78-911. Argued October 10, 1979. Decided July 2, 1980. Together with No. 78-1036, Marshall, Secretary of Labor v. American Petroleum Institute et al., also on certiorari to the same court.

The Occupational Safety and Health Act of 1970 (Act) delegates broad authority to the Secretary of Labor (Secretary) to promulgate standards to ensure safe and healthful working conditions for the Nation's workers (the Occupational Safety and Health Admissions (OSHA) being the agency responsible for carrying out this authority). Section 3(8) of the Act defines an "occupational safety and health standard" as a standard that is "reasonably necessary or appropriate to provide safe or healthful employment." Where toxic materials or harmful physical agents are concerned, a standard must also comply with 6(b)(5), which directs the Secretary to "set the standard which most adequately assures, to the extent feasible, on the basis of the best available evidence, that no employee will suffer material impairment of health or functional capacity." When the toxic material or harmful physical agent to be regulated is a carcinogen, the Secretary has taken the position that no safe exposure level can be determined and that 6(b)(5) requires him to set an exposure limit at the lowest technologically feasible level that will not impair the viability of the industries

regulated. In this case, after having determined that there is a causal connection between benzene (a toxic substance used in manufacturing such products as motor fuels, solvents, detergents, and pesticides) and leukemia (a cancer of the white blood cells), the Secretary promulgated a standard reducing the permissible exposure limit on airborne concentrations of benzene from the consensus standard of 10 parts benzene per million parts of air (10 ppm) to 1 part benzene per million parts of air (1 ppm), and prohibiting dermal contact with solutions containing benzene. On pre-enforcement review, the Court of Appeals held the standard invalid because it was based on findings unsupported by the administrative record. The court concluded that OSHA had exceeded its standard-setting authority because it had not been shown that the 1 ppm exposure limit was "reasonably necessary or appropriate to provide safe and healthful employment" as required by 3(8), and that [448 U.S. 607, 608] 6(b)(5) did not give OSHA the unbridled discretion to adopt standards designed to create absolutely risk-free workplaces regardless of cost.

APPENDIX J

AUTOMOBILE WORKERS v. JOHNSON CONTROLS, INC.,

499 U.S. 187 (1991)

International Union, United Automobile, Aerospace and Agricultural Implement Workers of American, UAW, et al. v. Johnson Controls, Inc. Certiorari to the United States Court of Appeals for the Seventh Circuit No. 89-1215. Argued October 10, 1990. Decided March 20, 1991.

A primary ingredient in respondent's battery manufacturing process is lead, occupational exposure to which entails health risks, including the risk of harm to any fetus carried by a female employee. After eight of its employees became pregnant while maintaining blood lead levels exceeding that noted by the Occupational Safety and Health Administration (OSHA) as critical for a worker planning to have a family, respondent announced a policy barring all women, except those whose infertility was medically documented, from jobs involving actual or potential lead exposure exceeding the OSHA standard. Petitioners, a group including employees affected by respondent's fetal-protection policy, filed a class action in the District Court, claiming that the policy constituted sex discrimination violative of Title VII of the Civil Rights Act of 1964, as amended. The court granted summary judgment for respondent, and the Court of Appeals affirmed. The latter court held that the proper standard for evaluating the policy was the business necessity inquiry applied by other Circuits; that respondent was entitled to summary judgment because petitioners had failed to satisfy

their burden of persuasion as to each of the elements of the business necessity defense under Wards Cove Packing Co. v. Atonio, 490 U.S. 642; and that, even if the proper evaluative standard was bona fide occupational qualification (BFOQ) analysis, respondent still was entitled to summary judgment because its fetal-protection policy is reasonably necessary to further the industrial safety concern that is part of the essence of respondent's business.

Held: Title VII, as amended by the Pregnancy Discrimination Act (PDA), forbids sex-specific fetal-protection policies (pp. 197-211).

(a) By excluding women with childbearing capacity from lead-exposed jobs, respondent's policy creates a facial classification based on gender and explicitly discriminates against women on the basis of their sex under 703(a) of Title VII. Moreover, in using the words "capable of bearing children" as the criterion for exclusion, the policy explicitly classifies on the basis of potential for pregnancy, which classification must be 499 U.S. 187, 188 regarded, under the PDA, in the same light as explicit sex discrimination. The Court of Appeals erred in assuming that the policy was facially neutral because it had only a discriminatory effect on women's employment opportunities, and because its asserted purpose, protecting women's unconceived offspring, was ostensibly benign. The policy is not neutral, because it does not apply to male employees in the same way as it applies to females, despite evidence about the debilitating effect of lead exposure on the male reproductive system. Also, the absence of a malevolent motive does not convert a facially discriminatory policy into a neutral policy with a discriminatory effect. Cf. Phillips v.

Martin Marietta Corp., 400 U.S. 542. Because respondent's policy involves disparate treatment through explicit facial discrimination, the business necessity defense and its burden-shifting under Wards Cove are inapplicable here. Rather, as indicated by the Equal Employment Opportunity Commission's enforcement policy, respondent's policy may be defended only as a BFOQ, a more stringent standard than business necessity (pp. 197-200).

(b) The language of both the BFOQ provision set forth in 703(e)(1) of Title VII – which allows an employer to discriminate on the basis of sex "in those certain instances where ... sex ... is a [BFOQ] reasonably necessary to the normal operation of [the] particular business" – and the PDA provision that amended Title VII – which specifies that, unless pregnant employees differ from others "in their ability or inability to work," they must be "treated the same" as other employees "for all employment-related purposes" - as well as these provisions' legislative history and the case law, prohibit an employer from discriminating against a woman because of her capacity to become pregnant unless her reproductive potential prevents her from performing the duties of her job. The so-called safety exception to the BFOQ is limited to instances in which sex or pregnancy actually interferes with the employee's ability to perform, and the employer must direct its concerns in this regard to those aspects of the woman's job-related activities that fall within the "essence" of the particular business. Dothard v. Rawlinson, 433 U.S. 321, 333, 335; Western Air Lines, Inc. v. Criswell, 472 U.S. 400, 413. The unconceived fetuses of respondent's female employees are neither customers nor third parties whose safety is essential to the business of battery manufacturing (pp. 200-206).

(c) Respondent cannot establish a BFOQ. Fertile women, as far as appears in the record, participate in the manufacture of batteries as efficiently as anyone else. Moreover, respondent's professed concerns about the welfare of the next generation do not suffice to establish a BFOQ of female sterility. Title VII, as amended by the PDA, mandates that decisions about the welfare of future children be left to the parents 499 U.S. 187, 189 who conceive, bear, support, and raise them, rather than to the employers who hire those parents or the courts (pp. 206-207).

(d) An employer's tort liability for potential fetal injuries and its increased costs due to fertile women in the workplace do not require a different result. If, under general tort principles, Title VII bans sex-specific fetal-protection policies, the employer fully informs the woman of the risk, and the employer has not acted negligently, the basis for holding an employer liable seems remote, at best. Moreover, the incremental cost of employing members of one sex cannot justify a discriminatory refusal to hire members of that gender. See Los Angeles Dept. of Water & Power v. Manhart, 435 U.S. 702, 716-718, and n.32 (pp. 208-211).

886 F.2d 871 (CA7 1989), reversed and remanded.

Table 1
Estimated 2000 U.S. Census Coverage Error on U.S. Population (1999-2004)

Total	Population	Net		
		-0.1%		
Females Ages 16 - 49	134,502,033	134,502		
	Age			
Race-Ethnicity/Hispanic Grouping (race4cat)	20-29	Net	30-49	Net
Non-Black Females				
uncorrected	5,825,898	-1.94%	6,524,398	-1.01%
corrected	5,938,920	+113,022	6,590,294	+65,896
Black Females				
uncorrected	3,746,816	-0.66%	7,286,247	+1.28%
corrected	3,771,545	+24,729	7,192,983	-93,264

Note . Adapted from *Summary of Accuracy and Coverage Evaluation for Census 2000* by M. Mulry, 2006. Washington, D.C.: Statistical Research Division, U.S. Census Bureau.

Table 2
Childbearing-Aged Female Participants Interviewed by Age
(1999-2004)

Frequency Row Pct. Col. Pct.	1999-2000	2001-2002	2003-2004	Total
16y - 19y 192m - 239m	1,168 (27.71%) (35.50%)	1,499 (35.56%) (33.48%)	1,548 (36.73%) (37.77%)	4,215 (35.52%)
20y - 29y 240m - 359m	794 (28.04%) (21.70%)	1,164 (38.29%) (26.00%)	1,082 (35.59%) (26.40%)	3,040 (25.62%)
30y - 39y 360m - 479m	714 (28.05%) (24.14%)	1,033 (40.57%) (23.07%)	799 (31.38%) (19.50%)	2,546 (21.46%)
40y - 49y 480m - 599m	614 (29.75%) (18.66%)	781 (37.84%) (17.44%)	669 (32.41%) (16.33%)	2,064 (17.40%)
Total	3,290 (27.73%)	4,477 (37.73%)	4,098 (34.54%)	11,865 (100.00%)

Table 3
Childbearing-Aged Female Participants Examined by Age
(1999-2004)

Frequency Row Pct. Col. Pct.	1999-2000	2001-2002	2003-2004	Total
16y - 19y 192m - 239m	1,090 (26.97%) (35.56%)	1,450 (35.87%) (33.54%)	1,502 (37.16%) (37.97%)	4,042 (35.63%)
20y - 29y 240m - 359m	745 (25.40%) (24.31%)	1,121 (38.22%) (25.93%)	1,067 (36.38%) (26.97%)	2,933 (25.86%)
30y - 39y 360m - 479m	659 (27.38%) (21.50%)	1,004 (41.71%) (23.07%)	744 (30.91%) (18.81%)	2,407 (21.22%)
40y - 49y 480m - 599m	571 (29.10%) (18.63%)	748 (38.12%) (17.30%)	643 (32.77%) (16.25%)	1,962 (17.30%)
Total	3,065 (27.02%)	4,323 (38.11%)	3,956 (34.87%)	11,344 (100.00%)

95.61% interviewed were examined

Table 4
Childbearing-Aged Female Participants in Laboratory Subsample by Age
(1999-2004)

Frequency Row Pct. Col. Pct.	1999-2000	2001-2002	2003-2004	Total
16y - 19y 192m - 239m	288 (21.80%) (33.26%)	468 (35.43%) (32.01%)	565 (42.77%) (40.94%)	1,321 (35.62%)
20y - 29y 240m - 359m	235 (23.64%) (27.14%)	395 (39.74%) (27.02%)	364 (36.62%) (26.38%)	994 (26.81%)
30y - 39y 360m - 479m	207 (25.31%) (23.90%)	361 (44.13%) (24.69%)	250 (30.56%) (18.12%)	818 (22.06%)
40y - 49y 480m - 599m	136 (23.65%) (15.70%)	238 (41.39%) (16.28%)	201 (34.96%) (14.57%)	575 (15.51%)
Total	866 (23.35%)	1,462 (39.43%)	1,380 (37.22%)	3,708 (100.00%)

32.69% examined were sampled

Table 5
Childbearing-Aged Female Participants Sampled for Lead, Any Mercury and Any PCBs of Interest[1] by Age and Race-Ethnicity (1999-2004)

Laboratory Tests	Lead	Mercury 1 THg or IHg	Mercury 2 THg + IHg	PCBs 1 - 3	PCBs 4
16y - 19y 192m - 239m	1,282	10	1,245	13	1,173
20y - 29y 240m - 359m	977	11	966	6	923
30y - 39y 360m - 479m	776	12	761	7	743
40y - 49y 480m - 599m	563	7	556	1	534
Non-Hispanic White	1,678	23	1,644	7	1,571
Non-Hispanic Black	733	12	715	2	682
Mexican-	855	4	839	14	798
Other Hispanic	189	0	188	2	183
Other Racial	143	1	142	2	139
Total	3,598	40 (1.08%)	3,528	25 (0.67%)	3,373
All Hispanic	1,044	4	1,027	16	981

Table 6
Childbearing-Aged Female Participants Sampled for All Chemicals of Interest[1] and Reliable Dietary Recall[2] by Age and Race-Ethnicity (1999-2004)

Study Criteria	Incomplete Sample	Complete Sample	Unreliable Dietary Recall	Reliable Dietary Recall	Chemicals and Reliable Dietary Recall[3]
16y - 19y 192m - 239m	185	1,136	60	1,261	1,085
20y - 29y 240m - 359m	82	912	37	957	884
30y - 39y 360m - 479m	91	727	33	785	702
40y - 49y 480m - 599m	46	529	28	547	502
Non-Hispanic White	200	1,536	55	1,681	1,493
Non-Hispanic Black	95	666	51	710	623
Mexican-	93	782	44	831	745
Other Hispanic	10	182	4	188	178
Other Racial	6	138	4	140	134
Total	404 (11.98%)	3,304	158 (4.26%)	3,550	3,173
All Hispanic	103 (10.68%)	964	48 (4.71%)	1,019	923

[1]Chemicals of Interest = Lead (Pb), Total Mercury (THg), Inorganic Mercury (IHg), Polychlorinated Biphenyl (PCB) Congeners 118, 138, 153 and 180

[2]NHANES Interviewers' Rating: Reliable and Meets Minimum Criteria for Dietary Recall (DRDDRSTS = 1)

[3]Total loss to sample: 535 (14.43%)

Table 7
Childbearing-Aged Females with All Chemical Tests[1] and Reliable Dietary Recall[2] by Age and Race-Ethnicity (unweighted and weighted data 1999-2004)

	Sample (unweighted)	U.S. Population (weighted)	Percent (weighted)
16y - 19y 192m - 239m	1,085	18,510,469	14%
20y - 29y 240m - 359m	884	45,347,515	34%
30y - 39y 360m - 479m	702	36,357,837	27%
40y - 49y 480m - 599m	502	34,286,213	25%
Non-Hispanic White	1,493	97,887,544	73%
Non-Hispanic Black	623	12,747,178	9%
Mexican-American	745	8,670,576	6%
Other Hispanic	178	7,525,992	6%
Other Racial	134	7,670,743	6%
Total	3,173	134,502,033	100%
All Hispanic (race4cat)	923	16,196,568	12%

[1]Chemicals of Interest = Lead (Pb), Total Mercury (THg), Inorganic Mercury (IHg), Polychlorinated Biphenyl (PCB) Congeners 118, 138, 153 and 180

[2]NHANES Interviewers' Rating: Reliable and Meets Minimum Criteria for Dietary Recall (DRDDRSTS = 1)

Table 8
Pregnant Childbearing-Aged Participants Examined by Age (1999-2004)

Frequency Row Pct. Col. Pct.	1999-2000	2001-2002	2003-2004	Total
16y - 19y 192m - 239m	55 (28.20%) (14.75%)	65 (33.34%) (12.10%)	75 (38.46%) (18.84%)	195 (14.91%)
20y - 29y 240m - 359m	193 (28.98%) (51.74%)	285 (42.79%) (53.07%)	188 (28.23%) (47.24%)	666 (50.91%)
30y - 39y 360m - 479m	120 (27.39%) (32.17%)	186 (42.47%) (34.64%)	132 (30.14%) (33.17%)	438 (33.49%)
40y - 49y 480m - 599m	5 (55.55%) (1.34%)	1 (11.11%) (0.19%)	3 (33.34%) (0.75%)	9 (0.69%)
Total	373 (28.52%)	537 (41.05%)	398 (30.43%)	1,308 (100.00%)

11.53% examined were pregnant

Table 9
Pregnant Childbearing-Aged Participants in Laboratory Subsample by Age (1999-2004)

Frequency Row Pct. Col. Pct.	1999-2000	2001-2002	2003-2004	Total
16y - 19y 192m - 239m	17 (23.29%) (15.04%)	23 (31.51%) (11.33%)	33 (45.20%) (25.00%)	73 (16.29%)
20y - 29y 240m - 359m	63 (28.25%) (55.75%)	108 (48.43%) (53.20%)	52 (23.32%) (39.39%)	223 (49.78%)
30y - 39y 360m - 479m	33 (22.00%) (29.20%)	71 (47.33%) (34.98%)	46 (30.67%) (34.85%)	150 (33.48%)
40y - 49y 480m - 599m	0 (0.00%) (0.00%)	1 (50.00%) (0.49%)	1 (50.00%) (0.76%)	2 (0.45%)
Total	113 (25.22%)	203 (45.31%)	132 (29.47%)	448 (100.00%)

34.25% examined and pregnant were sampled

Table 10
Pregnant Childbearing-Aged Participants Sampled for Lead, Any Mercury and Any PCBs of Interest[1] by Age and Race-Ethnicity (1999-2004)

Laboratory Tests	Lead	Mercury 0 or 1 THg or IHg	Mercury 2 THg + IHg	PCBs 0 - 3	PCBs 4
16y - 19y 192m - 239m	70	3	70	12	61
20y - 29y 240m - 359m	219	4	219	19	204
30y - 39y 360m - 479m	139	11	139	16	134
40y - 49y 480m - 599m	2	0	2	0	2
Non-Hispanic White	212	11	212	23	200
Non-Hispanic Black	60	2	60	5	57
Mexican-	116	5	116	17	104
Other Hispanic	23	0	23	0	23
Other Racial	19	0	19	2	17
Total	430	18 (4.02%)	430	47 (11.72%)	401
All Hispanic	139	5	139	2	127

Table 11
Pregnant Childbearing-Aged Participants Sampled for All Chemicals of Interest[1] and Reliable Dietary Recall[2] by Age and Race-Ethnicity (1999-2004)

Study Criteria	Incomplete Laboratory Sample	Complete Laboratory Sample	Unreliable Dietary Recall	Reliable Dietary Sample	Chemicals and Reliable Dietary Recall[3]
16y - 19y 192m - 239m	12	61	1	72	61
20y - 29y 240m - 359m	19	204	8	215	198
30y - 39y 360m - 479m	16	134	9	141	130
40y - 49y 480m - 599m	0	2	0	2	2
Non-Hispanic White	23	200	7	216	198
Non-Hispanic Black	5	57	2	60	55
Mexican-	17	104	7	114	100
Other Hispanic	0	23	2	21	21
Other Racial	2	17	0	19	17
Total	47 (10.49%)	401	18 (4.02%)	430	391
All Hispanic	2 (4.76%)	40	9 (6.25%)	135	121

[1]Chemicals of Interest = Lead (Pb), Total Mercury (THg), Inorganic Mercury (IHg), Polychlorinated Biphenyl (PCB) Congeners 118, 138, 153 and 180

[2]NHANES Interviewers' Rating: Reliable and Meets Minimum Criteria for Dietary Recall (DRDDRSTS = 1)

[3]Total loss to sample: 57 (12.72%)

Table 12
Pregnant Childbearing-Aged Females with All Chemical Tests[1] and Reliable Dietary Recall[2] by Age and Race-Ethnicity
(unweighted and weighted data 1999-2004)

	Survey Sample (unweighted)	U.S. Population (weighted)	Percent (weighted)
16y - 19y 192m - 239m	61	404,786	8%
20y - 29y 240m - 359m	198	2,562,931	53%
30y - 39y 360m - 479m	130	1,687,711	35%
40y - 49y 480m - 599m	2	186,761	4%
Non-Hispanic White	198	3,035,932	63%
Non-Hispanic Black	55	713,663	15%
Mexican-American	100	487,086	10%
Other Hispanic	21	263,559	5%
Other Racial	17	341,950	7%
Total	391	4,842,189	100%
All Hispanic	121	750,645	15%

[1]Chemicals of Interest = Lead (Pb), Total Mercury (THg), Inorganic Mercury (IHg), Polychlorinated Biphenyl (PCB) Congeners 118, 138, 153 and 180

[2]NHANES Interviewers' Rating: Reliable and Meets Minimum Criteria for Dietary Recall (DRDDRSTS = 1)

Table 13
Bivariate Analyses of Season, Time of Day, Food Fast and Food Consumption on Exposure as Outcome with Two Categories
(unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
	Exposure					
	0 and 1		2 and 3			
Season (ridexmon)						
November - April	758.00 (45.31%) 19,285,399.56 (34.39%)		674.00 (44.93%%) 29,365,343.47 (37.44%)		0.045 *0.83*	0.71 *0.40*
May - October	915.00 (54.69%) 36,779,061.09 (65.61%)		826.00 (55.07%%) 49,072,229.30 (62.56%)			
missing	n = 0 dropped					
Time of Day (time)						
Morning	784.00 (46.86%) 23,790,488.75 (42.43%)		740.00 (49.33%) 39,470,876.92 (50.32%)			
Afternoon	529.00 (31.62%) 18,079,471.03 (32.25%)		497.00 (33.13%) 25,478,512.93 (32.48%)		7.96 *0.019*	1.79 *0.18*
Evening	360.00 (21.52%) 14,194,500.87 (25.32%)		263.00 (17.53%) 13,488,182.92 (17.20%)			
(missing)	n = 0 dropped					
Food Fast prior 24 hours (fdfstcat)						
more than 24h	* (0.00%) 218,749.31 (0.39%)		* (0.00%) 278,855.06 (0.36%)			
16 to <24	224.00 (13.39%) 7,576,698.02 (13.51%)		188.00 (12.53%) 9,937,588.75 (12.67%)			
8 to <16	850.00 (50.81%) 28,726,744.41 (51.24%)		820.00 (54.67%) 434,029,49.11 (55.33%)		9.68 *0.085*	0.69 *0.63*
4 to <8	434.00 (25.94%) 16,101,400.57 (28.72%)		383.00 (25.53%) 21,902,865.77 (27.92%)			
1 to <4	140.00 (8.37%) 3,150,722.27 (5.62%)		89.00 (5.93%) 2,454,735.57 (3.13%)			
< 1 hr	* (0.00%) 290,146.07 (0.52%)		* (0.00%) 460,578.49 (0.59%)			
(missing)	n = 0 dropped					
Food Consumption prior 24-hours (fdc3cat)						
usual^{R}	976.00 (58.48%) 33,526,112.21 (59.92%)		917.00 (61.13%) 51,357,582.93 (65.48%)			
less than usual	462.00 (27.68%) 15,416,115.31 (27.55%)		399.00 (26.60%) 19,344,149.41 (%)		6.36 *0.095*	0.687 *0.51*
more than usual	231.00 (13.84%) 7,007,328.05 (12.52%)		184.00 (12.27%) 7,735,840.43 (9.86%)			
(missing)	n = 4 dropped					

Table 14. Percent Bias in Estimating the Geometric Mean and Standard Deviation by Imputation Method

Method	% Nondetectable	Percent Bias in Estimating the Geometric Mean				Percent Bias in Estimating the Geometric Standard Deviation			
		Geometric Standard Deviation				Geometric Standard Deviation			
		1.5	2.0	2.5	3.0	1.5	2.0	2.5	3.0
	0	0.05	-0.04	-0.2	0.02	0.12	-0.04	-0.01	-0.05
1	15	0.4	0.5	0.0	-0.4	0.3	0.3	-0.3	0.4
2		-7.2	-5.2	-3.2	-1.8	13.4	8.1	4.2	1.0
3		-2.2	-0.1	1.9	3.4	2.9	-1.0	-4.2	-6.6
1	30	-0.3	0.2	-0.1	0.2	-0.3	0.3	-0.6	-0.4
2		-12.3	-7.4	-3.8	11.2	16.8	7.2	0.4	-4.5
3		-2.6	2.8	6.9	11.2	1.7	-5.8	-11.4	-15.4
1	45	0.3	-0.1	0.2	0.2	0.4	-0.3	0.3	0.4
2		-16.0	-7.2	0.3	6.1	15.3	1.9	-6.9	-13.5
3		-1.8	8.4	17.1	24.1	-1.5	-12.2	-19.4	-24.8
1	60	-	-	-	-	-	-	-	-
2		-17.9	-4.2	8.4	19.8	10.1	-6.1	-16.6	-24.2
3		1.1	17.9	33.4	47.3	-6.1	-19.3	-27.9	-34.4

Note : 1 = Hald, 2 = Nehls & Akland, 3 = Hornung & Reed. Adapted from "Estimation of Average Concentration in the Presence of Nondetectable Values," by R. Hornung and L. Reed, 1990, *Applied Occupational and Environmental Hygiene. 5* (1), p. 49-50. Copyright Taylor and Francis, Ltd.

Table 15
Limits of Detection and Imputed Values of Xenobiotic Blood Levels for Hornung and Reed (1990) Calculations: NHANES Sample Population by Each Two-Year Period[1]

Dependent Variable Components	1999 - 2000	2001-2002	2003-2004
Lead LBXBPB Non-Detectables[2] = 385/45,195 (0.9%) Detectables = 44,810/45,195 (99.1%)	LBXBPB = 0.3/√2 = 0.212 or 0.2 µg/dl Non-Detectables[2] = 75/12,582 (0.6%) Mode of Detectable Values Only: 0.80 GStandard Deviation of Log Detectable Values: 0.65 Skewness/GSkewness: 8.97/0.397	LBXBPB = 0.3/√2 = 0.212 or 0.2 µg/dl Non-Detectables[2] = 271/16,828 (1.6%) Mode of Detectable Values Only: 0.90 GStandard Deviation of Log Detectable Values: 0.67 Skewness/GSkewness: 7.29/0.44	LBXBPB = 0.3/√2 = 0.212 or 0.2 µg/dl Non-Detectables[2] = 39/15,785 (0.25%) Mode of Detectable Values Only: 0.90 GStandard Deviation of Log Detectable Values: 0.65 Skewness/GSkewness: 9.32/0.53
Total Mercury LBXTHG Non-Detectables[2] = 1,233/24,362 (5.1%) Detectables = 23,129/24,362 (94.9%)	LBXTHG = 0.137/√2 = 0.097 or 0.1 µg/dl Non-Detectables[2] = 308/3,605 (8.5%) Mode of Detectable Values Only: 0.30 GStandard Deviation of Log Detectable Values: 1.01 Skewness/GSkewness: 4.92/0.47	LBXTHG = 0.1/√2 = 0.07 µg/dl Non-Detectables[2] = 262/4,972 (5.3%) Mode of Detectable Values Only: 0.20 GStandard Deviation of Log Detectable Values: 1.01 Skewness/GSkewness: 5.17/0.22	LBXTHG = 0.14/√2 = 0.099 or 0.1 µg/dl Non-Detectables[2] = 663/15,785 (4.2%) Mode of Detectable Values Only: 0.30 GStandard Deviation of Log Detectable Values: 1.01 Skewness/GSkewness: 5.85/0.31
Inorganic Mercury LBXIHG Non-Detectables[2] = 20,029/23,929 (83.7%) Detectables = 3,900/23,929 (16.3%)	LBXIHG = 0.446/√2 = 0.315 or 0.3 µg/dl Non-Detectables[2] = 3,491/3,582 (97.5%) Mode of Detectable Values Only: 0.50 GStandard Deviation of Log Detectable Values: 0.83 Skewness/GSkewness: 3.26/2.06	LBXIHG = 0.396/√2 = 0.28 µg/dl Non-Detectables[2] = 4,641/4,901 (94.7%) Mode of Detectable Values Only: 0.50 GStandard Deviation of Log Detectable Values: 0.45 Skewness/GSkewness: 8.86/3.08	LBXIHG = 0.446/√2 = 0.315 or 0.3 µg/dl Non-Detectables[2] = 11,897/15,446 (77.0%) Mode of Detectable Values Only: 0.40 GStandard Deviation of Log Detectable Values: 0.36 Skewness/GSkewness: 41.81/2.09
PCB 118 LBX118 Non-Detectables[2] = 4,749/12,261 (38.7%) Detectables = 7,512/12,261 (61.3%)	LBD118LC = 1[3] Non-Detectables[2] = 2,181/3,322 (65.65%) Mode of Detectable Values Only: 0.06 GStandard Deviation of Log Detectable Values: 0.74 Skewness/GSkewness: 8.34/0.69	LBD118LC = 1[3] Non-Detectables[2] = 2,568/4,922 (52.17%) Mode of Detectable Values Only: 0.04 GStandard Deviation of Log Detectable Values: 0.74 Skewness/GSkewness: 7.26/0.91	LBD118LC = 1[3] Non-Detectables[2] = 0/4,017 (0%) Mode of Detectable Values Only: 0.01 GStandard Deviation of Log Detectable Values: 0.95 Skewness/GSkewness: 12.29/1.15
PCB 138 LBX138 Non-Detectables[2] = 3,473/12,243 (28.4%) Detectables = 8,770/12,243 (71.6%)	LBD138LC = 1[3] Non-Detectables[2] = 2,318/3,326 (69.7%) Mode of Detectable Values Only: 0.16 GStandard Deviation of Log Detectable Values: 0.58 Skewness/GSkewness: 7.58/0.90	LBD138LC = 1[3] Non-Detectables[2] = 1,155/4,880 (23.7%) Mode of Detectable Values Only: 0.05 GStandard Deviation of Log Detectable Values: 0.92 Skewness/GSkewness: 4.29/0.50	LBD138LC = 1[3] Non-Detectables[2] = 4,037/4,037 (0%) Mode of Detectable Values Only: 0.02 GStandard Deviation of Log Detectable Values: 1.13 Skewness/GSkewness: 8.81/0.58
PCB 153 LBX153 Non-Detectables[2] = 3,019/12,265 (24.6%) Detectables = 9,246/12,265 (75.4%)	LBD153LC = 1[3] Non-Detectables[2] = 2,156/3,313 (65.1%) Mode of Detectable Values Only: 0.37 GStandard Deviation of Log Detectable Values: 0.59 Skewness/GSkewness: 6.83/0.65	LBD153LC = 1[3] Non-Detectables[2] = 863/4,921 (17.5%) Mode of Detectable Values Only: 0.03 GStandard Deviation of Log Detectable Values: 1.01 Skewness/GSkewness: 3.88/0.34	LBD153LC = 1[3] Non-Detectables[2] = 4,031/4,031 (0%) Mode of Detectable Values Only: 0.03 GStandard Deviation of Log Detectable Values: 1.19 Skewness/GSkewness: 7.49/0.45
PCB 180 LBX180 Non-Detectables[2] = 3,801/12,251 (31.0%) Detectables = 8,450/12,251 (69%)	LBD180LC = 1[3] Non-Detectables[2] = 2,043/3,304 (61.8%) Mode of Detectable Values Only: 0.26 GStandard Deviation of Log Detectable Values: 0.65 Skewness/GSkewness: 4.70/0.30	LBD180LC = 1[3] Non-Detectables[2] = 1,719/4,908 (35.0%) Mode of Detectable Values Only: 0.03 GStandard Deviation of Log Detectable Values: 0.96 Skewness/GSkewness: 3.58/0.19	LBD180LC = 1[3] Non-Detectables[2] = 39/4,039 (0.9%) Mode of Detectable Values Only: 0.01 GStandard Deviation of Log Detectable Values: 1.37 Skewness/GSkewness: 5.18/0.26

[1]with no missing data [2]Non-Detectables = Below Level of Detection [3]PCBs' Level of Detection is Sample-Specific G = Geometric Values

Table 16
Initial Calculations for Methylmercury (MeHg) Blood Levels NHANES Sample Population by Each Two-Year Period

	1999-2000					2001-2002					2003-2004				1999-2004
MeHg < 0	IHg^{1} (<LoD) 0.3	IHg (LoD) 0.446	IHg (>LoD) > 0.446	Subtotal	MeHg < 0	IHg^{1} (<LoD) 0.28	IHg (LoD) 0.396	IHg (>LoD) > 0.396	Subtotal	MeHg < 0	IHg^{1} (<LoD) 0.3	IHg (LoD) 0.446	IHg (>LoD) > 0.446	Subtotal	Total MeHg < 0
THg^{1} (< LoD) 0.1	302	0	2	304	THg^{1} (< LoD) 0.07	254	0	5	259	THg^{1} (< LoD) 0.1	597	14	30	641	1,204
THg (LoD) 0.137	258	1	4	263	THg (LoD) 0.1	192	0	1	193	THg (LoD) 0.137	997	70	76	1,143	1,599
THg >IHgLoD - IHg >LoD > 0.137 to 0.446	0	0	0	0	THg >IHgLoD - IHg >LoD > 0.1 to 0.396	415	8	27	450	THg >IHgLoD - IHg >LoD > 0.137 to 0.446	710	134	246	1,090	1,540
THg (>IHgLoD) > 0.446	0	0	0	0	THg (>IHgLoD) > 0.396	0	0	5	5	THg (>IHgLoD) > 0.446	0	0	60	60	65
Total	560	1	6	567	Total	861	8	38	907	Total	2,304	218	412	2,934	4,408 (18.44%)

	1999-2000					2001-2002					2003-2004				1999-2004
MeHg = 0	IHg^{1} (<LoD) 0.3	IHg (LoD) 0.446	IHg (>LoD) > 0.446	Subtotal	MeHg = 0	IHg^{1} (<LoD) 0.28	IHg (LoD) 0.396	IHg (>LoD) > 0.396	Subtotal	MeHg = 0	IHg^{1} (<LoD) 0.3	IHg (LoD) 0.446	IHg (>LoD) > 0.446	Subtotal	Total MeHg = 0
THg^{1} (< LoD) 0.1	0	0	0	0	THg^{1} (< LoD) 0.07	0	0	0	0	THg^{1} (< LoD) 0.1	0	0	0	0	0
THg (LoD) 0.137	0	0	0	0	THg (LoD) 0.1	0	0	0	0	THg (LoD) 0.137	0	0	0	0	0
THg >IHgLoD - IHg >LoD > 0.137 to 0.446	292	0	0	292	THg >IHgLoD - IHg >LoD > 0.1 to 0.396	0	1	0	1	THg >IHgLoD - IHg >LoD > 0.137 to 0.446	1,232	89	0	1,321	1,614
THg (>IHgLoD) > 0.446	0	0	0	0	THg (>IHgLoD) > 0.396	0	0	6	6	THg (>IHgLoD) > 0.446	0	0	87	87	93
Total	292	0	0	292	Total	0	1	6	7	Total	1,232	89	87	1,408	1,707 (7.14%)

	1999-2000					2001-2002					2003-2004				1999-2004
MeHg > 0	IHg^{1} (<LoD) 0.3	IHg (LoD) 0.446	IHg (>LoD) > 0.446	Subtotal	MeHg > 0	IHg^{1} (<LoD) 0.28	IHg (LoD) 0.396	IHg (>LoD) > 0.396	Subtotal	MeHg > 0	IHg^{1} (<LoD) 0.3	IHg (LoD) 0.446	IHg (>LoD) > 0.446	Subtotal	Total MeHg > 0
THg^{1} (< LoD) 0.1	0	0	0	0	THg^{1} (< LoD) 0.07	0	0	0	0	THg^{1} (< LoD) 0.1	0	0	0	0	0
THg (LoD) 0.137	0	0	0	0	THg (LoD) 0.1	0	0	0	0	THg (LoD) 0.137	0	0	0	0	0
THg >IHgLoD - IHg >LoD > 0.137 to 0.446	238	0	0	238	THg >IHgLoD - IHg >LoD > 0.1 to 0.396	786	0	0	786	THg >IHgLoD - IHg >LoD > 0.137 to 0.446	1,146	0	0	1,146	2,170
THg (>IHgLoD) > 0.446	2,396	6	75	2,477	THg (>IHgLoD) > 0.396	2,983	28	179	3,190	THg (>IHgLoD) > 0.446	7,214	901	1,838	9,953	15,620
Total	2,634	6	75	2,715	Total	3,769	28	179	3,976	Total	8,360	901	1,838	11,099	17,790 (74.42%)

MeHg = (THg-IHg) THg = Total Mercury LoD = Level of Detection n = 23,905

IHg = Inorganic Mercury [1] = NHANES' imputed value = LoD/√2

Table 17
Operational Definitions of Independent Variables

Variable Name [R] = Reference Group (missing) = *not* separate category	Operational Definitions
Susceptibility-Related Attributes	
Age	
Age (age4cat)	age in months (RIDAGEMN)
16y - 19y[R]	192 - 239 months
20y - 29y	240 - 359 months
30y - 39y	360 - 479 months
40y - 49y	480 - 599 months
(missing)	n = 0 dropped
Health Status	
Perceived Health Status (huq2cat)	"Would you say your health in general is ..." (HUQ010)
excellent, very good, good[R]	
fair, poor	
(missing)	n = 1 dropped
Co-Morbidities (CCMS3cat)	"Has a doctor or other health professional ever told you that you have…" (See Table 23)
(missing)	recoded as no
Iron Deficiency (FeD2cat)	(See Table 24)
Treatment for Iron Deficiency past 3 mo (FeTx2cat)	"During the past 3 months, have you been on treatment for anemia, sometimes called 'tired blood' or 'low blood'? [include diet, iron pills, iron shots, transfusions as treatment]" (MCQ053)
yes	
no[R]	
(missing)	n = 1 dropped
Iron Deficiency and Treatment (FeDTx)	(FeD2cat * FeTx2cat)
(missing)	n = 1 dropped
Health Insurance (hi2cat)	"What kind of health insurance or health care coverage do you have? Include those that pay for only one type of service (nursing home care, accidents, or dental care). Exclude private plans that only provide extra cash while hospitalized. If {you have/he/she has} more than one kind of health insurance, just tell me about the first kind." (HID010, HID030)
private[R]	plan from employer, purchased directly from insurance, state/local government or community programs
public	medicare, medi-gap, medicaid, CHIP, military, tricare, Indian health service, state plan, other gov't
none	
missing	n = 73
Regular Source of Healthcare (hp2cat)	Is there a place that you usually go when you are sick or you need advice about your health?(HUQ030)
yes[R]	one or more places
no	
(missing)	n = 0
Source of Healthcare (hcsre)	"What kind of place do you go to most often: is it a clinic, doctor's office, emergency room, or some other place?" (HUQ040)
healthcare provider[R]	doctor's office or HMO
clinic	clinic or health center
ER or none	emergency room, hospital outpatient department, other unnamed source or none
missing	n = 48
Nutritional Status	
Food Security (food2cat)	household food security (FSDHH) + adult food security (FSDAD) + child food security (FSDCH)
food secure[R]	household fully or marginally secure or exceeds poverty income ratio (INDFMPIR ≥ 5);
food insecure	household insecure without hunger or household insecure with hunger
missing	n = 142
Body Mass Index (bmi30cat)	(BMXBMI)
<30.0[R] underweight, normal, overweight	underweight 00.0 to < 18.5 normal 18.5 to < 25.0 overweight 25.0 to < 30.0
30.0+ obese	obese I 30.0 to < 35.0 obese II 35.0 to < 40.0 obese III 40.0 or more
missing	n = 39

Table 17
Operational Definitions of Independent Variables

Variable Name R = Reference Group . = missing or (missing) = *not* separate category	Operational Definitions
Fat Intake/AMDR (fat3cat)	(fat intake 24h * 9 g/cal) /(total caloric intake 24h) (DR1TTFAT*9/DR1TKCAL) See Table 25
recommended or less[R]	0.00 to 0.35
more than recommended	> 0.35
(missing)	n = 0
Protein Intake in past 24h/AMDR (prot3cat)	(protein intake 24h * 4 g/cal) /(total caloric intake 24h) (DR1TPROT*4/DR1TKCAL) See Table 25
recommended or more[R]	0.10 or more
less than recommended	0.00 to < 0.10
(missing)	n = 0
Iron Intake in past 24h/RDA (iron2cat)	(dr1tiron/RDA) See Table 25
recommended or more[R]	≥ 1.0
less than recommended	< 1.0
(missing)	n = 0
Calcium Intake in past 24h/RDA (calc2cat)	(dr1tcalc/RDA) See Table 25
recommended or more[R]	≥ 1.0
less than recommended	< 1.0
(missing)	n = 0
Selenium Intake in past 24h/RDA (sele2cat)	(dr1tsele/RDA) See Table 25
recommended or more[R]	≥ 1.0
less than recommended	< 1.0
(missing)	n = 0
Reproductive Status	
Current Pregnancy (pregnant)	urine pregnancy test (URXPREG) and trimester of pregnancy (RHD152)
pregnant	urine pregnancy test (URXPREG = 1) OR if urine pregnancy test (URXPREG = .) AND trimester of pregnancy (RHD152 = 4, 5, 6, 7, 8, or 9)
not pregnant[R]	urine pregnancy test (URXPREG = 2)
missing	urine pregnancy test (URXPREG = .) OR if urine pregnancy test (URXPREG = .) AND trimester of pregnancy (RHD152 = 1, 2, or 3) unknown n = 141
Trimester of Pregnancy (tripcorr)	"Think that you are pregnant now?" (RHQ140 = 1) THEN "What month of pregnancy are you in?" (RHD152) and urine pregnancy test (URXPREG=1)
1st trimester	trimester of pregnancy (RHD152 = 1, 2, or 3) AND urine pregnancy test (URXPREG ≠ 2) OR urine pregnancy test (URXPREG = 1) AND trimester of pregnancy (RHD152 ≠ 4-9)
2nd trimester	trimester of pregnancy (RHD152 = 4, 5, 6)
3rd trimester	trimester of pregnancy (RHD152 = 7, 8, 9)
not pregnant[R]	urine pregnancy test (URXPREG = 2 or .) OR trimester of pregnancy (RHD152 = .) if unknown, recoded as not pregnant
Ever Pregnant (tprg2cat)	"The next questions are about your pregnancy history. {Have you ever been pregnant? Please include current pregnancy, live births, miscarriages, stillbirths, tubal pregnancies and abortions." (RHQ131)
never pregnant[R]	(RHQ131 = 2) OR (PREGNANT = 2)
one or more pregnancies	(RHQ131 = 1) OR (PREGNANT = 1)
(missing)	recoded as never pregnant
Live Births (live)	"How many of your pregnancies resulted in a live birth?" (RHD170)
no live births[R]	
one or more live births	
missing	recoded as no live births
Ever Breastfed (brstfda)	"Are you now breastfeeding a child?" (RHQ200) AND/OR "How many of your children did you breastfeed for at least one month?" (RHD230)
never breastfed[R]	
breastfed more than one month or currently	
missing	recoded as never breastfed

Table 17
Operational Definitions of Independent Variables

Variable Name R = Reference Group . = missing or (missing) = *not* separate category	Operational Definitions
Exposure-Related Attributes	
Acculturation	
Birthplace (born2cat)	"In what country were you born?" (DMDBORN)
U.S.R	
outside U.S.	
(missing)	n = 0
Years in U.S. (yrus5)	"In what month and year did you come to the United States to stay?" (DMDYRSUS)
born in U.S.R	(DMDBORN = 1)
five or more years	survey year - year arrived in U.S. (SDDSRVYR - DMDYRSUS)
less than five years	survey year - year arrived in U.S. (SDDSRVYR - DMDYRSUS)
(missing)	n = 6 dropped
Language Spoken at Home (lang2cat)	In general, what language(s) do you speak at home? (ACD010) For Hispanics Only: Would you say you speak/read . . . (ACQ020)
EnglishR	Only English OR English AND another language OR more English than Spanish OR both English and Spanish equally
Other	one or more languages (neither English) OR more Spanish than English
(missing)	n = 2 dropped
U.S. Citizenship (usczn2cat)	"Are you a citizen of the United States?" [Information about citizenship is being collected by the U.S. Public Health Service to perform health related research. Providing this information is voluntary and is collected under the authority of the Public Health Service Act. There will be no effect on pending immigration or citizenship petitions.]
U.S. citizenR	
non-U.S. citizen	
(missing)	n = 1 dropped
Dietary Consumption	
Seafood Eaten in Past 30 Days (smpw2cat)	see below fish eaten in past 30 days (fish2cat) AND shellfish eaten in past 30 days (shell2cat)
noneR	
any	
(missing)	recoded as none
Fish Eaten in Past 30 Days (fish2cat)	"During the past 30 days did you eat any types of fish listed on this card? Include any foods that had fish in them such as sandwiches, soups, or salads." (DRD360 AND DRD370)
noneR	
any	
(missing)	recoded as none
Shellfish Eaten in Past 30 Days (shell2cat)	"During the past 30 days did you eat any types of shellfish listed on this card? Include any foods that had shellfish in them such as sandwiches, soups, or salads." (DRD340 AND DRD350)
noneR	
any	
(missing)	recoded as none
Tap Water Consumed Prior 24h (tap2kct)	"How much of the plain water you drank was home tap water (1 gram = 1 milliliter)?" (DR1_330)
noneR	
< 2,000 ml	
2,000+ ml	
missing	n = 211
Alcohol Consumption	
Alcohol Consumption (retohuse)	
never, seldom drinkerR *including 16-19 y/o*	Never: "In your entire life, have you had at least 12 drinks of any type of alcoholic beverage?"(ALQ101 = 2) Included are liquor (such as whiskey or gin), beer, wine, wine coolers, and any other type of alcoholic beverage. Seldom: "In any one year, have you had at least 12 drinks of any type of alcoholic beverage? By a drink, I mean a 12 oz. beer, a 4 oz. glass of wine, or an ounce of liquor." (ALQ100 = 2) information confidential; assumed never or seldom drinker
drinker	"In any one year, have you had at least 12 drinks of any type of alcoholic beverage?"(ALQ100 = 1)
heavy drinker	"In the past 12 months, on how many days did you have five or more drinks of any alcoholic beverage?" (ALQ140Q/ALQ140U > 1) Was there ever a time or times in your life when you drank five or more drinks of any kind of alcoholic beverage almost every day?" (ALQ150 = 1)
missing	n = 145

Table 17
Operational Definitions of Independent Variables

Variable Name R = Reference Group . = missing or (missing) = *not* separate category	Operational Definitions
Tobacco Use	
Self-Reported Tobacco Use (tobuse)	cigarettes, pipe, cigars, snuff, chaw, other nicotine products ever/never (smq020 + smq120 + smq150 + smq180 + smq210 + smq840) current/former (smq040 + smq140 + smq170 + smq200 + smq230 + smq840)
age restricted[R]	(smq020 = missing + age4cat = 1)
never	
former	
current	
missing	n = 15 dropped
Serum Cotinine (cot3cat)	(lbxcot)
< 1.0 ng/ml[R]	
1.0 - 10.0 ng/ml	
> 10.0 ng/ml	
(missing)	n = 15 dropped
Environmental Tobacco Smoke (ETS)	"I would now like to ask you a few questions about smoking. Does anyone who lives here smoke cigarettes, cigars, or pipes anywhere inside this home?" (SMD410 = 1) "What is the total number of (cigarette, cigar, pipe) smokers in home?" (SMD415 > 0) "At your job or business, how many hours per day can you smell the smoke from other people's cigarettes, cigars, and/or pipes?" (OCQ290G ≥ 1)
no ETS[R]	
ETS at home or work	
ETS at home and work	
(missing)	recoded as no ETS
Residence	
Tap Water Source (h2os2cat)	"What is the source of tap water in this home? Is it a private or public water company, a private or public well, or something else?" (HOQ070)
public[R]	municipality or company
private	well or something else
missing	n = 81
Residential Tap Water Treatment (h2ox2cat)	"Are any of these water treatment devices used in your home (listed)?" (HOQ080)
yes	
no[R]	
missing	n = 71
Type of Residence (res3cat)	"I'd like to ask you a few questions about your home. Is your home . . ." (HOD011)
attached or detached house[R]	
mobile home or trailer	
all other types	
(missing)	recoded as all other types
Age of Residence (resb60cat)	"When was this {mobile home/house/building} originally built?" (HOD040)
1960 or newer[R]	
older than 1960	
missing/unknown	n = 812 (25.59%)
Age of Residence (resb78cat)	"When was this {mobile home/house/building} originally built?" (HOD040)
1978 or newer[R]	
older than 1978	
missing/unknown	n = 812 (25.59%)
Resident Status (resd3cat)	"Is this {mobile home/house/apartment} owned, being bought, rented, or occupied by some other arrangement by you or someone else in your family?" (HOQ065)
own[R]	
rent	
other	
(missing)	recoded as other
Years at Current Residence (re5yrcat)	"How many years {have you/has your family} lived at this address?" (HOD060/5)
more than five years[R]	
five years or less	
missing	n = 53
Household Size (hsize)	Total number of people in the Household (DMDHHSIZ)
four persons or less[R]	
more than four persons	

Table 17
Operational Definitions of Independent Variables

Variable Name R = Reference Group . = missing or (missing) = *not* separate category	Operational Definitions
Rooms in Residence (rm3cat)	"How many rooms are in this home? Count the kitchen but not the bathroom." (HOD050)
7+ rooms[R]	
4-6 rooms	
1-3 rooms	
missing	n = 71
Occupation	
Current Occupation (cocc2cat)	"What kind of work were you doing?" (OCD240) See Tables 23 and 24
not working[R]	
management, professional & sales	
services & goods	
(missing)	n = 0
Time in Current Employment (cjt)	"About how long have you worked for {EMPLOYER} as a(n) {OCCUPATION)?" (OCD270/5)
not working[R]	
less than five years	
five or more years	
(missing)	n = 0
Total Hours Worked Prior Week (hrwk)	"How many hours did you work last week at all jobs or businesses?" (OCD180/35) "Do you usually work 35 hours or more per week in total at all jobs or businesses?" (OCD210)
not employed[R]	employment status (emp3cat)
less than 35 hours	
35+ hours	
(missing)	n = 2 dropped
Longest Held Occupation (locc2cat)	"Thinking of all the paid jobs or businesses you ever had, what kind of work were you doing the longest? (OCD390) See Table
not applicable[R]	
management, professional & sales	
services & goods	
(missing)	n = 0
Time in Longest Employment (ljt)	"About how long did {you/SP} work at that job or business?" (OCD395)
not applicable[R]	
less than five years	
five or more years	
(missing)	n = 0
Socioeconomic Factors	
Education	
Highest Education (educ2)	"What is the highest grade or level of school {you have/SP has} completed or the highest degree {you have/s/he has} received?" (DMDEDUC2, DMDEDUC3)
high school diploma, GED or higher[R]	
less than high school diploma	
(missing)	n = 1 dropped
Employment	
Employment Status (emp3cat)	"In this part of the survey I will ask you questions about your work experience. Which of the following were you doing last week… (OCD150)
employed	
not employed[R]	
(missing)	n = 2 dropped
Reason for Unemployment (unem2cat)	"What is the main reason you did not work last week?" (OCD380)
working[R]	employment status (emp3cat)
voluntary unemployment	taking care of house or family; going to school; retired
involuntary unemployment	unable to work for health reasons; on layoff; disabled; other
missing	n = 101
Work History (wkcp)	longest held occupation (locc2cat) AND current occupation (cocc2cat) AND employment status (emp3cat)
never employed[R]	
currently employed	
employed in the past but not currently	
employed now and in the past	
(missing)	recoded as never employed

Table 17
Operational Definitions of Independent Variables

Variable Name R = Reference Group . = missing or (missing) = *not* separate category	Operational Definitions
Income	
U.S. Poverty Threshold (pov2cat)	Family Poverty Income Ratio (INDFMPIR) See Table 25
more than 1.00[R]	
1.00 or less	
missing	n = 216
Marital Status	
Marital Status (marr3cat)	"Are you now married, widowed, divorced, separated, never married or living with a partner?"
married or living with partner	
widowed, divorced or separated	
never married[R]	
missing	n = 77
Race-Ethnicity	
Race-Ethnicity (race5cat)	"Which one of these groups would you say best represents your race?" (RIDRETH1)
Non-Hispanic White[R]	
Non-Hispanic Black	
Mexican American	
Other Hispanic	
Asian, Native American, Pacific Islander & Multi-Racial	includes "cannot choose 1 race"
(missing)	n = 0
Race-Ethnicity/Hispanic Grouping (race4cat)	"Which one of these groups would you say best represents your race?" (RIDRETH1)
Non-Hispanic White[R]	
Non-Hispanic Black	
Hispanic	Mexican American AND Other Hispanic
Asian, Native American, Pacific Islander & Multi-Racial	includes "cannot choose 1 race"
(missing)	n = 0

Table 18
Composition and Frequencies of Independent Variables that Comprise the Charleson Co-Morbidity Index (1999-2004)

Index Points Per Diagnosis Sample Frequency * = cell size less than 30	0	1	2	3	6
Myocardial Infarction (MCQ160E)	3,166.00	*			
Congestive Heart Failure (MCQ160B)	3,169.00	*			
Cerebrovascular Disease (MCQ160F)	3,156.00	*			
Chronic Pulmonary Disease asthma + chronic bronchitis + emphysema (MCQ010+MCQ030) + (MCQ160K+MCQ170K) + (MCQ160G)	2,920.00	253.00			
Diabetes (DIQ010)	3,110.00	63.00			
Connective Tissue Disease[1]					
Peripheral Vascular Disease[1]					
Liver Disease - mild CTP[2] score + MCQ160L + MCQ170L = 5 points or less	3,173.00	0.00			
Peptic Ulcer[3] (MCQ200 1 = Yes 2 = No)	3,162.00	*			
Dementia[1,4]					
Renal Disease moderate to severe kidney failure/dialysis or serum creatinine ≤ 3.0 mg/dL (KIQ020 or LBXSCR)	3,171.00		*		
Diabetes with End-Organ Disease diabetes with retinopathy or dialysis (DIQ010+ DIQ080 or DIQ090 or KIQ200)	3,158.00		*		
Hemiplegia/Paraplegia[1]					
Solid Tumor with no metastases within five years[5] (MCQ220 + MCQ230A-DD) + (RIDAGEYR-MCQ240A-DD)	3,152.00		*		
History of Leukemia (MCQ220 + MCQ230 A/ B/ C or D = 21)	3,172.00		*		
History of Lymphoma (MCQ220 + MCQ230 A/ B/ C or D = 24)	3,172.00		*		
Liver Disease - moderate to severe CTP2 score + MCQ160L + MCQ170L = 6 points or more	3,173.00			0.00	
Solid Tumor with metastases[5]	3,168.00				*
AIDS-Complex HIV positive + CD4 < 200 cells/mm^3	3,171.00				*

References

Charlson, Charlson, Peterson, Marinopoulos, Briggs, & Hollenberg, (2008). The Charlson comorbidity index is adapted to predict costs of chronic disease in primary care patients. *Journal of Clinical Epidemiology, 61* , 1234-1240. doi:10:1016/j.jclinepi.2008.01.006

Charlson, Pompei, Ales, & MacKenzie, (1987). A new method of classifying prognostic comorditiy in longitudinal studies: development and validation. *Journal of Chronic Diseases, 40* , 377, 382-383.

Table 18
Composition and Frequencies of Independent Variables that Comprise the Charleson Co-Morbidity Index (1999-2004)

[1]Information Not Available in NHANES (1999 - 2004)					
Score Points Sample Frequency * = cell size less than 30	1	2	3	4	Total
[2]Childs-Turcotte-Pugh Score (CTP) serum albumin + serum total bilirubin + (prothrombin time[1] + ascites[1] + hepatic encephalopathy[1])		2,941.00	227.00	*	3,173.00
Serum Albumin (sal3cat)					
more than 35.0 mg/dl	2,941.00	*	*		2,957.00
28.0 - 35.0 mg/dl	0.00	212.00	0.00		212.00
less than 28.0 mg/dl	0.00	0.00	*		*
Serum Total Bilirubin (stb3cat)					
less than 34.0	2,799.00	302.00	56.00		3,157.00
34.0 - 50.0	*	0.00	0.00		*
more than 50.0	0.00	*	0.00		*
Prothrombin Time[1] 1 (13.0 - 16.9) or 2(17.0 - 19.0) or 3(> 19.0)					
Ascites[1] (1 = None or 2 = Mild/Controlled or 3 = Severe/Refractory)					
Hepatic Encephalopathy[1] (1 = None or 2 = Grades I-II/Controlled or 3 = Grades III-IV/Refractory)					
Sample Frequency * = cell size less than 30	0 never	1 ever			
[3]Peptic Ulcer (MCQ200)					
1999 - 2000	787.00	*			
2001 - 2004[1]	2,375.00	N/A			
[4]Dementia (chronic cognitive deficit) memory problems (PFQ056 + PFQ059) + unable to manage money (PFQ059)					
16 - 19[1]	1,085.00	N/A			
20 - 29	880.00	*			
30 -39	702.00	0.00			
40 - 49	501.00	*			
[5]Solid Tumor excludes leukemia, lymphoma, blood and bone cancers (MCQ220 + MCQ230A-DD)					
Solid Tumor with no metastases within five years (MCQ220 + MCQ230A-DD) + (RIDAGEYR-MCQ240A-DD)	3,152.00	21.00			
Solid Tumor with metastases (MCQ220 + MCQ230A-DD + 66)	3,168.00	*			
	Primary Site	Secondary Site	Secondary-to-Tertiary Site		
Metastasic Cancers in childbearing-aged female participants		nervous system	lung-to-breast		
	cervix	*			
	ovary	*			
	uterus		*		

[1]Information Not Available in NHANES (1999 - 2004)

References

Brodaty, H., Pond, D., Kemp, N., Luscombe, G., Harding, L., Berman, K., & Huppert, F. (2002). The GPCOG: a new screening test for dementia designed for general practice. *Journal of American Geriatric Society, 50* (3), 530-534. doi:10.1046/j.1532-5415.2002.50122.x

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Pugh, R., Murray-Lyon, I., Dawson, J., Pietroni, M. & Williams, R. (1973, August). Transection of the oesophagus for bleeding oesophageal varices. *The British Journal of Surgery, 60* (8), 646-649.

Table 19
Composition and Frequencies of Independent Variables that Comprise Iron Deficiency (1999-2004)

Points Sample Frequency * = cell size less than 30	0	1	2+	Total
Iron Deficiency ≥ 2 points	2,021.00 (63.69%)	703.00 (22.16%)	449.00 (14.15%)	3,173.00
Mean Cell Volume (LBXMCVSI)				
81.0 fL or more	2,021.00	651.00	272.00	2,944.00
less than 81.0 fL	0.00	52.00	177.00	229.00
Transferin Saturation (LBXPCT) (serum iron / serum total iron binding capacity x 100%)				
15% or more	2,021.00	276.00	*	2,316.00
less than 15%	0.00	427.00	430.00	857.00
Serum Ferritin (LBXFERSI)				
12 or more µg/L	2,021.00	479.00	41.00	2,541.00
less than 12 µg/L	0.00	224.00	408.00	632.00

fL = femtoliters = 10^{-15} liters

References

Móron, C., & Viteri, F. (2009). Update on common indicators of nutritional status: food access, food consumption and biochemical measures of iron and anemia. *Nutrition Reviews, 67* (Supplement 1), S31-S35. doi:10.1111/j.1753-4887.2009.00156.x

Ross, E. (2002). Evaluation and Treatment of Iron Deficiency in Adults. *Nutrition in Clinical Care* , 5(5), 220-224.

Table 20
Composition and Frequencies of Independent Variables that Comprise Acceptable Macronutrient Distribution Range (AMDR) and Recommended Daily Allowances (RDA) for Specific Nutrients (1999-2004)

	Age 192 to < 240 mo	Age ≥ 240 to < 600 mo
Fat AMDR (fat3cat)	0.25 to 0.35	0.20 to 0.35
Protein AMDR (prot3cat)	0.10 to 0.30	0.10 to 0.35
Iron RDA (iron2cat)		
Pregnant (pregnant = 1)	27 mg	27 mg
Breastfeeding (RHQ200 = 1)	10 mg	9 mg
Neither Pregnant (pregnant = 2 or 3) Nor Breastfeeding (RHQ200 = 2)	15 mg	18 mg
Calcium RDA (calc2cat)		
Pregnant (pregnant= 1)	1,300 mg	1,000 mg
Breastfeeding (RHQ200= 1)	1,300 mg	1,000 mg
Neither Pregnant (pregnant = 2 or 3) Nor Breastfeeding (RHQ200 = 2)	1,300 mg	1,000 mg
Selenium RDA (sele2cat)		
Pregnant (pregnant = 1)	60 µg	60 µg
Breastfeeding (RHQ200 = 1)	70 µg	70 µg
Neither Pregnant (pregnant = 2 or 3) Nor Breastfeeding (RHQ200 = 2)	55 µg	55 µg
Water RDA all sources		
Pregnant (pregnant = 1)	3,000	3,000
Breastfeeding (RHQ200 = 1)	3,800	3,800
Neither Pregnant (pregnant = 2 or 3) Nor Breastfeeding (RHQ200 = 2)	2,300	2,700

References

Institute of Medicine. (2005). Dietary Reference Intakes. Washington, DC: National Academy Press.

Table 21
NHANES Post-Recall Dietary Questionnaire Specific
Fish/Shellfish (1999-2004)

Shellfish Meals
Clams
Crab
Crayfish
Lobster
Mussels
Oysters
Scallops
Shrimp
Other Shellfish
Other Unknown Shellfish
Fish Meals
Breaded Fish Products
Tuna
Bass
Catfish
Cod
Flatfish
Haddock
Mackerel
Perch
Pike
Pollock
Porgy
Salmon
Sardines
Sea Bass
Shark
Swordfish
Trout
Walleye
Other Fish
Other Fish Unknown

References

Centers for Disease Control and Prevention, National Center for Health Statistics. (2007b, November). NHANES 2003-2004 Data Documentation: Dietary Interview Total Nutrient Intakes (First Day). Retrieved February 7, 2011 from http://www.cdc.gov/nchs/data/nhanes/nhanes_03_04/dr1tot_c.pdf

Table 22

Limits of Detection and Imputed Values of Serum Cotinine Levels for Hornung and Reed (1990) Calculations NHANES Sample Population by Each Two-Year Period[1]

Independent Variable	1999 - 2000	2001-2002	2003-2004
Serum Cotinine LBXCOT Non-Detectables[2] = 10,763/42,931 (25.1%) Detectables = 32,168/42,931 (74.9%)	LBXCOT = 0.05/√2 = 0.035 µg/dl Non-Detectables[2] = 4,480/11,767 (38.07%) Mode of Detectable Values Only: 0.035 GStandard Deviation of Log Detectable Values: 2.944 Skewness: 0.676	LBXCOT= 0.05/√2 = 0.035 µg/dl or LBXCOT = 0.15/√2 = 0.011 µg/dl Non-Detectables[2] = 3,937/16,071 (24.49%) Mode of Detectable Values Only: 0.011 GStandard Deviation of Log Detectable Values: 3.219 Skewness: 0.791	LBXCOT = 0.15/√2 = 0.011 µg/dl Non-Detectables[2] = 2,346/15,093 (15.54%) Mode of Detectable Values Only: 0.011 GStandard Deviation of Log Detectable Values: 3.214 Skewness: 0.819

[1]with no missing data [2]Non-Detectables = Below Level of Detection

Table 23
Composition of Independent Variables that Comprise Industrial Categories
(1999-2004)

Industrial Categories	NAICS Census 2000
Goods-Producing Industries	
Natural Resources & Mining	001 - 056
agriculture production	
agricultural services, forestry and fishing	
mining	
Construction	077 - 106
construction	
Manufacturing	107 - 406
food and kindred products	
textile mill products	
apparel and other finished textile products	
paper products, printing, publishing and allied industries	
chemicals, petroleum and coal products	
rubber, plastics and leather products	
lumber and wood products including furniture	
metal industires	
machiery except electrical	
electrical machinery, equipment and supplies	
transportation equipment	
miscellaneous and not specified manufacturing industries	
Services-Producing Industries	
Trade, Transportation & Utilities [1]	407 - 646; 057 - 076
trucking service	
transportation except trucking	
utilities	
wholesale trade, durable goods	
whoelsale trade, non-durable and not specified goods	
retail department stores	
retail food stores	
retail vehicle dealers, supply and service stores	
retail eating and drinking places	
other retail trade	
Information/Communications	647 - 686
information/communications	
Financial Activities	687 - 726
banking and other finance	
insurance and real estate	

Table 23
Composition of Independent Variables that Comprise Industrial Categories
(1999-2004)

Industrial Categories	NAICS Census 2000
Professional & Business Services	727 - 785
business services	
other professional and related services	
Other Services	877 - 936
repair services	
private households	
Leisure & Hospitality	856 - 876
lodging places	
personal services except private households and lodging	
entertainment and recreation services	
Education & Health Services	786 - 855
offices of health practitioners	
hospitals	
health services, n.e.c.	
educational services	
social services	
Public Administration	937 - 966
justice, public order and safety	
public administration except justice, public order and safety	
military and national security	
Unemployed	992
blank but applicable	

[1]Utilities reclassified from goods to services by NAICS in 1997

References

U.S. Census Bureau. (2001b, October). Occupation Detailed Code List: Decennial 2000 SOC and U.S. Census 2000. Retrieved February 7, 2011 from http://factfinder.census.gov/metadoc/occupation.pdf

U.S. Census Bureau. (2003a, March). North American Industry Classification System (NAICS) Index of Industry and Occupations: Alternate Aggregation Structure. Retrieved February 7, 2011 from http://www.dlt.ri.gov/lmi/pdf/alternate.pdf

Table 24
Composition of Independent Variables that Comprise Occupational Categories
(1999-2004)

Occupational Categories	Census 2000
Managerial and Professional Occupations	001-359
executive, administrators and managers	
management-related occupations	
farm operators, managers and supervisors	
engineers, architects and scientists	
health diagnosing, assessing and treating occupations	
teachers	
writers, artists, entertainers and athletes	
other professional specialty occupations	
technicians and related support occupations	
Sales-Related Occupations	470-599
supervisors and proprietors, sales occupations	
sales representatives, finance, business and commodities excluding retail	
sales workers, retail and personal services	
secretaries, stenographers and typists	
information clerks	
records processing occupations	
material recording, scheduling and distributing clerks	
miscellaneous administrative support occupations	
Services-Related Occupations	360-469
private household occupations	
protective service occupations	
waiters and waitresses	
cooks	
miscellaneous food preparation and service occupations	
health service occupations	
cleaning and building service occuaptions	
personal service occupations	
Farming, Fishing and Forestry Occupations	600-613
farm and nursery workers	
related agricultural, forestry and fishing occupations	
vehicle and mobile equipment mechanics and repairers	
other mechanics and repairers	
Construction, Extraction and Maintenance Occupations	620-769
construction trades	
extractive and prercision production occupations	
textile, apparel and furnishings machine operators	
machine operators, assorted materials	

Table 24
Composition of Independent Variables that Comprise Occupational Categories (1999-2004)

Occupational Categories	Census 2000
Production, Transportation and Material Moving Occupations	770-979
fabricators, assemblers, inspectors and samplers	
motor vehicle operators	
other transportation and material moving occupations	
construction laborers	
laborers excluding construction	
freight, stock and material movers, hand	
other helpers, equipment cleaners, hand packagers and laborers	

References

U.S. Census Bureau. (2001b, October). Occupation Detailed Code List: Decennial 2000 SOC and U.S. Census 2000. Retrieved February 7, 2011 from http://factfinder.census.gov/metadoc/occupation.pdf

U.S. Census Bureau. (2003a, March). North American Industry Classification System (NAICS) Index of Industry and Occupations: Alternate Aggregation Structure. Retrieved February 7, 2011 from http://www.dlt.ri.gov/lmi/pdf/alternate.pdf

Table 25
Composition and Frequencies of Independent Variables that Comprise Income-Related Variables (1999-2004)

	1999-2000	2001-2002	2003-2004
Family Poverty Income Ratio (INDFMPIR)[1]	1.00	1.00	1.00
Low Income Status (200%*INDFMPIR)	1.00	1.00	1.00
data missing or incomplete	n = 216 (6.81%)		
Median Family Income (MFI)	$ 49,628.00	$ 52,742.00	$ 53,692.00
Relative Poverty (60%*MFI)	$ 29,776.80	$ 31,645.00	$ 32,215.20
Housing Assistance Eligibility (50%*MFI)	$ 24,814.00	$ 26,371.00	$ 26,846.00
Annual Household Income (INDHHINC)	reported in ranges		
data missing or incomplete	n = 305 (10.40%)		
Annual Family Income (INDFMINC)	reported in ranges		
data missing or incomplete	n = 216 (6.81%)		

[1]before tax money income; poverty income threshold varies with age and family size

References

Assistant Secretary for Planning and Evaluation, U.S. Department of Health and Human Services. (January 25, 2010). *Further Resources on Poverty Measurement, Poverty Lines and Their History* . Retrieved February 7, 2011 from http://aspe.hhs.gov/poverty/contacts.shtml

Table 26
Frequencies of Independent Variables
(unweighted and weighted data 1999-2004)

Independent Variable Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Total
Susceptibility-Related Attributes	
Age (age4cat)	
	1,085.00
	(34.19%)
	18,510,468.72
16-19[R]	(13.76%)
	884.00
	(27.86%)
	45,347,514.91
20-29	(33.72%)
	702.00
	(22.13%)
	36,357,836.50
30-39	(27.03%)
	502.00
	(15.82%)
	34,286,213.30
40-49	(25.49%)
Health Status	
Perceived Health Status (huq2cat)	
	2,634.00
	(89.53%)
	124,005,245.09
excellent, very good, good[R]	(92.22%)
	332.00
	(10.47%)
fair, poor	10,465,879.59
	(7.78%)
missing = 1	
Charleson Co-Morbidity Scale (CCMS3cat)	
	2,814.00
	(88.69%)
	118,257,021.43
none[R]	(87.93%)
	303.00
	(9.55%)
	13,146,733.31
one co-morbidity	(9.77%)
	56.00
	(1.76%)
	3,098,278.69
more than one co-morbidity	(2.30%)
Iron Deficiency (FeD2cat)	
	2,724.00
	(85.85%)
	122,836,758.63
within normal limits[R]	(91.33%)
	449.00
	(14.15%)
	11,665,274.81
iron deficient	(8.67%)
Treatment for Iron Deficiency past 3 mo (FeTx2cat)	
	171.00
	(5.39%)
	5,146,295.97
yes	(3.83%)
	3,001.00
	(94.61%)
	129,342,158.39
no[R]	(96.17%)
missing = 1	

Table 26
Frequencies of Independent Variables
(unweighted and weighted data 1999-2004)

Independent Variable Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Total
Iron Deficiency and Treatment (FeDTx)	
	2,608.00
	(82.22%)
	119,442,698.68
normal/no treatment[R]	(88.81%)
	115.00
	(3.63%)
	3,380,480.87
normal w/treatment	(2.51%)
	56.00
	(1.76%)
	1,765,815.10
deficient w/treatment	(1.32%)
	393.00
	(12.39%)
	9,899,459.71
deficient/no treatment	(7.36%)
missing = 1	
Health Insurance (hi2cat)	
	2,042.00
	(64.35%)
	100,132,778.47
private[R]	(74.45%)
	439.00
	(13.83%)
	9,791,420.08
public	(7.28%)
	619.00
	(19.51%)
	21,762,804.37
none	(16.18%)
	73.00
	(2.31%)
	2,815,030.52
missing	(2.09%)
Regular Source of Healthcare (hp2cat)	
	2,673.00
	(84.84%)
	115,458,282.32
yes[R]	(85.58%)
	500.00
	(15.76%)
	19,043,751.11
no	(14.16%)
Source of Healthcare (hcsre)	
	1,807.00
	(56.95%)
	85,161,839.99
healthcare provider[R]	(63.32%)
	676.00
	(21.31%)
	23,768,096.88
clinic	(17.67%)
	642.00
	(20.23%)
	22,962,656.75
ER or none	(17.07%)
	48.00
	(1.51%)
	2,609,439.80
missing	(1.94%)

Table 26
Frequencies of Independent Variables
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Total
Nutritional Status	
Food Security (food2cat)	
	2,572.00
	(81.05%)
	114,043,912.66
food secure[R]	(84.79%)
	459.00
	(14.47%)
	14,234,522.05
food insecure	(10.58%)
	142.00
	(4.48%)
	6,223,598.72
missing	(4.63%)
Body Mass Index (bmi30cat)	
<30.0[R]	2,357.00
underweight	(74.28%)
normal	102,843,896.92
overweight	(76.46%)
	777.00
	(24.49%)
30.0+	30,216,437.80
obese	(22.47%)
	39.00
	(1.23%)
	1,441,678.71
missing	(1.07%)
Fat Intake/AMDR (fat3cat)	
	1,898.00
	(59.82%)
	81,144,342.04
recommended or less[R]	(60.33%)
	1,275.00
	(40.18%)
	53,357,691.39
more than recommended	(39.67%)
Protein Intake/AMDR (prot3cat)	
	2,712.00
	(85.47%)
	118,763,765.28
recommended or more[R]	(88.30%)
	461.00
	(14.53%)
	15,738,268.16
less than recommended	(11.70%)
Iron Intake/RDA (iron2cat)	
	929.00
	(29.28%)
	33,509,679.62
recommended or more[R]	(24.91%)
	2,244.00
	(70.72%)
	100,992,353.82
less than recommended	(75.09%)
Calcium Intake/RDA (calc2cat)	
	845.00
	(26.63%)
	42,562,543.92
recommended or more[R]	(31.64%)
	2,328.00
	(73.37%)
	91,939,489.51
less than recommended	(68.36%)

Table 26
Frequencies of Independent Variables
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Total
Selenium Intake/RDA (sele2cat)	
recommended or more[R]	2,559.00 (80.65%) 112,678,482.86 (83.77%)
less than recommended	614.00 (19.35%) 21,823,550.58 (16.23%)
Reproductive Status	
Current Pregnancy (pregnant)	
pregnant	391.00 (12.32%) 4,842,189.09 (3.60%)
not pregnant[R]	2,641.00 (83.23%) 126,376,518.93 (93.96%)
missing	141.00 (4.44%) 3,283,325.40 (2.44%)
Trimester of Pregnancy (tripcorr)	
not pregnant[R]	2,782.00 (87.68%) 129,659,844.35 (96.40%)
1st trimester	149.00 (4.69%) 1,991,566.11 (1.48%)
2nd trimester	132.00 (4.16%) 1,523,495.53 (1.13%)
3rd trimester	110.00 (3.47%) 1,327,127.44 (0.99%)
Ever Pregnant (tprg2cat)	
never pregnant[R]	1,535.00 (48.38%) 59,565,096.98 (44.29%)
one or more pregnancies	1,638.00 (51.62%) 74,936,936.45 (55.71%)
Live Births (live)	
no live births[R]	1,820.00 (57.36%) 67,420,238.21 (50.13%)
one or more live births	1,353.00 (42.64%) 67,081,795.21 (49.87%)

Table 26
Frequencies of Independent Variables
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Total
Ever Breastfed (brstfda)	
never breastfed[R]	2,323.00 (73.12%) 91,954,322.30 (68.37%)
breastfed more than one month and/or currently	850.00 (26.79%) 42,547,711.13 (31.63%)
Exposure-Related Attributes	
Acculturation	
Birthplace (born2cat)	
U.S.[R]	2,673.00 (84.24%) 120,303,696.80 (89.44%)
outside U.S.	500.00 (15.76%) 14,198,336.63 (10.56%)
Years in U.S. (yrus5)	
born in U.S.[R]	2,673.00 (84.40%) 120,303,696.80 (89.56%)
five or more years	352.00 (11.12%) 11,073,519.21 (8.24%)
less than five years	142.00 (4.48%) 2,960,966.91 (2.20%)
missing = 6	
Language Spoken at Home (lang2cat)	
English[R]	2,844.00 (89.69%) 126,761,194.36 (97.72%)
Other	327.00 (10.31%) 2,960,966.91 (2.28%)
missing = 2	
U.S. Citizenship (usczn2cat)	
U.S. citizen[R]	2,814.00 (88.71%) 126,825,271.91 (94.31%)
non-U.S. citizen	358.00 (11.29%) 7,654,892.84 (5.69%)
missing = 1	
Diet	
Seafood Eaten in Past 30 Days (smpw2cat)	
none[R]	686.00 (21.62%) 22,870,840.79 (17.01%)
any	2,487.00 (78.38%) 111,631,192.65 (82.99%)

Table 26
Frequencies of Independent Variables
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Total
Fish Eaten in Past 30 Days (fish2cat)	
	1,040.00
	(32.78%)
	36,809,739.68
none[R]	(27.37%)
	2,133.00
	(67.22%)
	97,692,293.76
any	(72.63%)
Shellfish Eaten in Past 30 Days (shell2cat)	
	1,557.00
	(49.07%)
	63,018,639.18
none[R]	(46.85%)
	1,616.00
	(50.93%)
	71,483,394.25
any	(53.15%)
Tap Water Consumed Prior 24h (tap2kct)	
	1,129.00
	(35.58%)
	40,504,828.24
none[R]	(30.12%)
	1,538.00
	(48.47%)
	71,045,485.42
< 2,000 ml	(52.82%)
	295.00
	(9.29%)
	15,529,552.50
2,000+ ml	(11.55%)
	211.00
	(6.66%)
	7,422,167.26
missing	(5.51%)
Alcohol Consumption	
Alcohol Consumption (retohuse)	
	1,743.00
	(54.93%)
never, seldom drinker[R]	52,220,515.36
including 16-19 y/o	(38.83%)
	730.00
	(23.01%)
	40,670,079.57
drinker	(30.24%)
	555.00
	(17.49%)
	35,765,379.44
heavy drinker	(26.59%)
	145.00
	(4.57%)
	5,846,059.05
missing	(4.34%)

Table 26
Frequencies of Independent Variables
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Total
Tobacco Use	
Serum Cotinine (cot3cat)	
< 1.0 ng/ml[R]	2,368.00 (74.99%) 98,871,473.57 (73.86%)
1.0 - 10.0 ng/ml	190.00 (6.02%) 5,250,301.62 (3.92%)
> 10.0 ng/ml	600.00 (18.99%) 29,750,341.24 (22.22%)
missing = 15	
ETS (ETS)	
no ETS[R]	2,417.00 (76.17%) 101,797,371.58 (75.68%)
ETS at home or work	650.00 (20.49%) 26,706,869.60 (19.86%)
ETS at home and work	106.00 (3.34%) 5,997,792.25 (4.46%)
Residence	
Tap Water Source (h2os2cat)	
public[R]	2,826.00 (89.06%) 116,735,908.16 (86.79%)
private	266.00 (8.38%) 14,491,535.02 (10.77%)
missing	81.00 (2.56%) 3,274,590.25 (2.44%)
Residential Tap Water Treatment (h2ox2cat)	
yes	863.00 (27.19%) 45,308,234.67 (33.69%)
no[R]	2,239.00 (70.56%) 86,545,337.36 (64.34%)
missing	71.00 (2.24%) 264,861.40 (1.98%)

Table 26
Frequencies of Independent Variables
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Total
Type of Residence (res3cat)	
	2,072.00
	(65.30%)
	89,305,970.56
attached or detached house[R]	(66.39%)
	202.00
	(6.37%)
	8,401,777.80
mobile home or trailer	(6.25%)
	899.00
	(28.33%)
all other types	36,794,285.07
including missing/unknown	(27.36%)
Age of Residence (resb60cat)	
	1,595.00
	(50.27%)
	78,044,524.02
1960 or newer[R]	(58.03%)
	766.00
	(24.14%)
	32,092,200.10
older than 1960	(23.86%)
	812.00
	(25.59%)
	24,365,309.31
missing/unknown	(18.11%)
Age of Residence (resb78cat)	
	1,087.00
	(34.26%)
	55,388,048.85
1978 or newer[R]	(41.18%)
	1,274.00
	(40.15%)
	54,748,695.27
older than 1978	(40.70%)
	812.00
	(25.59%)
	24,365,309.31
missing/unknown	(18.12)
Resident Status (resd3cat)	
	1,727,00
	(54.43%)
	77,250,307.12
own[R]	(57.43%)
	1,278.00
	(40.28%)
	51,163,895.57
rent	(38.04%)
	168.00
	(5.29%)
other	6,087,830.73
including missing	(4.53%)
Years at Current Residence (re5yrcat)	
	1,113.00
	(35.08%)
	45,894,318.68
more than five years[R]	(34.12%)
	2,007.00
	(63.25%)
	86,455,612.94
five years or less	(64.28%)
	53.00
	(1.67%)
	2,152,010.81
missing	(1.60%)

Table 26
Frequencies of Independent Variables
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Total
Household Size (hsize)	
four persons or less[R]	2,182.00 (68.77%) 106,454,028.39 (79.15%)
more than four persons	991.00 (31.23%) 28,048,005.05 (20.85%)
Rooms in Residence (rm3cat)	
7+ rooms[R]	1,148.00 (36.18%) 52,616,512.81 (39.12%)
4-6 rooms	1,691.00 (53.29%) 69,100,132.59 (51.37%)
1-3 rooms	263.00 (8.29%) 10,175,173.11 (7.57%)
missing	71.00 (2.24%) 2,610,214.92 (1.94%)
Occupation	
Current Occupation (cocc2cat)	
not working[R]	1,324.00 (41.73%) 42,172,957.57 (31.36%)
management, professional & sales	1,243.00 (39.17%) 67,758,891.74 (50.38%)
services & goods	606.00 (19.10%) 24,570,184.12 (18.26%)
Time in Current Employment (cjt)	
not working[R]	1,324.00 (41.73%) 42,172,957.57 (31.36%)
less than five years	1,434.00 (45.19%) 67,241,639.72 (49.99%)
five or more years	415.00 (13.08%) 25,087,436.13 (18.65%)
Total Hours Worked Prior Week (hrwk)	
not employed[R]	1,381.00 (43.55%) 45,808,038.02 (34.09%)
less than 35 hours	736.00 (23.21%) 33,367,433.79 (24.84%)
35+ hours	1,054.00 (33.24%) 55,181,521.00 (41.07%)
missing = 2	

Table 26
Frequencies of Independent Variables
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Total
Longest Held Occupation (locc2cat)	
not applicable[R]	1,562.00 (49.23%) 64,117,356.51 (47.67%)
management, professional & sales	903.00 (28.46%) 41,415,186.15 (30.79%)
services & goods	708.00 (22.31%) 28,969,490.47 (21.54%)
Time in Longest Employment (ljt)	
not applicable[R]	1,562.00 (49.23%) 64,117,356.51 (47.67%)
less than five years	997.00 (31.42%) 34,542,268.85 (25.68%)
five or more years	614.00 (19.35%) 35,842,408.07 (26.65%)
Socioeconomic Factors	
Education	
Highest Education (educ2)	
high school diploma, GED or higher[R]	2,037.00 (64.22%) 106,907,161.34 (79.52%)
less than high school diploma	1,135.00 (35.78%) 27,527,733.30 (20.48%)
missing = 1	
Employment	
Employment Status (emp3cat)	
employed	1,853.00 (58.44%) 92,468,799.96 (68.76%)
not employed[R]	1,318.00 (41.56%) 42,022,013.95 (31.24%)
missing = 2	
Reason for Unemployment (unem2cat)	
working[R]	1,853.00 (58.40%) 92,468,799.96 (68.75%)
voluntary unemployment	924.00 (29.12%) 28,265,021.67 (21.01%)
involuntary unemployment	295.00 (9.30%) 10,263,114.01 (7.63%)
missing	101.00 (3.18%) 3,505,097.78 (2.61%)

Table 26
Frequencies of Independent Variables
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	TOTAL
Work History (wkcp)	
never employed[R]	408.00 (12.86%) 8,238,810.80 (6.12%)
currently employed	1,154.00 (36.37%) 55,878,545.71 (41.55%)
employed in the past but not currently	916.00 (28.87%) 33,934,146.78 (25.23%)
employed now and in the past	695.00 (21.90%) 36,450,530.14 (27.10%)
Income	
U.S. Poverty Threshold (pov2cat)	
more than 1.00[R]	2,227.00 (70.19%) 103,953,623.19 (77.29%)
1.00 or less	730.00 (23.00%) 22,587,197.47 (16.79%)
missing	216.00 (6.81%) 7,961,212.77 (5.92%)
Marital Status	
Marital Status (marr3cat)	
married or living with partner	1,198.00 (37.75%) 61,800,648.25 (45.95%)
widowed, divorced or separated	261.00 (8.23%) 14,353,952.38 (10.67%)
never married[R]	1,637.00 (51.59%) 53,492,951.49 (39.77%)
missing	77.00 (2.43%) 4,854,481.31 (3.61%)

Table 26
Frequencies of Independent Variables
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	TOTAL
Race-Ethnicity	
Race-Ethnicity (race5cat)	
Non-Hispanic White[R]	1,493.00 (47.05%) 97,887,544.16 (72.78%)
Non-Hispanic Black	623.00 (19.63%) 12,747,178.37 (9.48%)
Mexican American	745.00 (23.49%) 8,670,575.81 (6.45%)
Other Hispanic	178.00 (5.61%) 7,525,992.22 (5.59%)
Asian, Native American, Pacific Islander & Multi-Racial	134.00 (4.22%) 7,670,742.88 (5.70%)
Race-Ethnicity/Hispanic Grouping (race4cat)	
Non-Hispanic White[R]	1,493.00 (47.05%) 97,887,544.16 (72.78%)
Non-Hispanic Black	623.00 (19.63%) 12,747,178.37 (9.48%)
Hispanic	923.00 (29.10%) 16,196,568.03 (12.04%)
Asian, Native American, Pacific Islander & Multi-Racial	134.00 (4.22%) 7,670,742.88 (5.70%)

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants
(unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
	Current Pregnancy (pregnant)					
Age (age4cat)	pregnant	not pregnant^{R}	missing			
16-19^{R}	(15.60%) 404,786.28 (8.36%)	(34.12%) 15,916,106.14 (12.59%)	(87.23%) 2,189,576.30 (66.69%)		388.32 *<0.0001*	7.77 *0.0000*
20-29	(50.64%) 2,562,930.76 (52.93%)	(25.60%) 42,139,552.13 (33.34%)	(0.00%) 645,032.0 (19.65%)			
30-39	(33.25%) 1,687,710.61 (34.85%)	(21.58%) 34,543,369.03 (27.33%)	(0.00%) 126,756.87 (3.86%)			
40-49	(0.00%) 186,761.44 (3.86%)	(18.71%) 33,777,491.63 (26.73%)	(0.00%) 321,960.23 (9.81%)			
	Live Births (live)					
Age (age4cat)	no live births^{R}	one or more live births				
16-19^{R}	992.00 (54.51%) 17,576,095.72 (26.07%)	93.00 (6.87%) 934,373.00 (1.39%)			1,097.32 *<0.0001*	37.14 *0.0000*
20-29	546.00 (30.00%) 33,032,255.38 (48.99%)	338.00 (24.98%) 12,315,259.53 (18.36%)				
30-39	189.00 (10.38%) 10,485,224.99 (15.55%)	513.00 (37.92%) 25,872,611.51 (38.57%)				
40-49	93.00 (5.11%) 6,326,662.12 (9.38%)	409.00 (30.23%) 27,959,551.18 (41.68%)				
	Ever Breastfed (brstfda)					
Age (age4cat)	never breastfed^{R}	breastfed more than one month or currently				
16-19^{R}	1,047.00 (45.07%) 18,135,863.89 (19.72%)	38.00 (4.47%) 374,604.83 (0.88%)			621.82 *<0.0001*	26.89 *0.0000*
20-29	669.00 (28.80%) 37,884,359.67 (41.20%)	215.00 (25.29%) 7,463,155.24 (17.54%)				
30-39	352.00 (15.15%) 18,595,942.83 (20.22%)	350.00 (41.18%) 17,761,893.68 (41.75%)				
40-49	255.00 (10.98%) 17,338,155.92 (18.86%)	247.00 (29.06%) 16,948,057.38 (39.83%)				

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value unweighted*	χ^2 *p value weighted*
	U.S. Poverty Threshold (pov2cat)					
Age (age4cat)	more than 1.00	1.00 or less	missing			
16-19^{R}	647.00 (29.05%) 12,250,212.93 (11.78%)	357.00 (48.90%) 4,716,875.65 (20.88%)	81.00 (37.50%) 1,543,380.14 (19.39%)			
20-29	639.00 (28.69%) 32,516,350.52 (31.28%)	183.00 (25.07%) 9,634,923.63 (42.66%)	62.00 (28.70%) 3,196,240.76 (40.15%)		107.59 *<0.0001*	4.16 *0.0021*
30-39	546.00 (24.52%) 29,389,193.20 (28.27%)	108.00 (14.79%) 4,451,494.54 (19.71%)	48.00 (22.22%) 2,517,148.76 (31.62%)			
40-49	395.00 (17.74%) 29,797,866.54 (28.66%)	82.00 (11.23%) 3,783,903.65 (16.75%)	* (0.00%) 704,443.11 (8.85%)			
	Time in Current Employment (cjt)					
Age (age4cat)	not working^{R}	less than five years	five or more years			
16-19^{R}	659.00 (49.77%) 10,401,116.38 (24.66%)	413.00 (28.80%) 7,917,836.01 (11.78%)	* (0.00%) 191,516.34 (0.76%)			
20-29	287.00 (21.68%) 11,681,897.31 (27.70%)	532.00 (37.10%) 30,433,333.24 (45.26%)	65.00 (15.66%) 3,232,284.36 (12.88%)		608.37 *<0.0001*	14.94 *0.0000*
30-39	214.00 (16.16%) 10,375,482.65 (24.60%)	332.00 (23.15%) 17,671,355.71 (26.28%)	156.00 (37.59%) 8,310,998.15 (33.13%)			
40-49	164.00 (12.39%) 9,714,461.24 (23.03%)	157.00 (10.95%) 11,219,114.77 (16.68%)	181.00 (43.61%) 13,352,637.29 (53.22%)			
	Time in Longest Employment (ljt)					
Age (age4cat)	not applicable^{R}	less than five years	five or more years			
16-19^{R}	584.00 (37.99%) 9,124,957.53 (14.23%)	497.00 (49.85%) 9,365,372.71 (27.11%)	* (0.00%) 20,138.48 (0.06%)			
20-29	398.00 (25.48%) 19,804,736.22 (30.89%)	367.00 (36.81%) 18,212,333.88 (52.72%)	119.00 (19.38%) 7,330,444.80 (20.45%)		778.16 *<0.0001*	19.79 *0.0000*
30-39	320.00 (20.49%) 16,623,205.52 (25.93%)	79.00 (7.92%) 3,839,684.30 (11.12%)	303.00 (49.35%) 15,894,946.68 (44.35%)			
40-49	260.00 (16.65%) 18,564,457.23 (28.95%)	54.00 (5.42%) 3,124,877.96 (9.05%)	188.00 (30.62%) 12,596,878.11 (35.15%)			

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
	Marital Status (marr3cat)					
Age (age4cat)	married or living with partner	widowed, divorced or separated	never married	missing		
16-19^{R}	62.00 (5.18%) 704,745.98 (1.14%)	* (0.00%) 115,609.26 (0.81%)	1,014.00 (61.94%) 17,678,830.80 (33.05%)	* (0.00%) 11,282.68 (0.23%)		
20-29	363.00 (30.30%) 15,242,297.90 (24.66%)	32.00 (12.26%) 1,286,019.58 (8.96%)	461.00 (28.16%) 27,402,743.76 (51.23%)	* (0.00%) 1,416,453.67 (29.18%)	1,589.54 *<0.0001*	15.82 *0.0000*
30-39	468.00 (39.07%) 23,431,086.70 (37.91%)	91.00 (34.87%) 4,769,461.14 (33.23%)	110.00 (6.72%) 5,921,247.56 (11.07%)	33.00 (42.86%) 2,236,041.11 (46.06%)		
40-49	305.00 (25.46%) 22,422,517.68 (36.28%)	132.00 (50.57%) 8,182,862.39 (57.01%)	52.00 (3.18%) 2,490,129.38 (4.66%)	* (0.00%) 1,190,703.85 (24.53%)		
	Charleson Co-Morbidity Scale (CCMS3cat)					
Perceived Health Status (huq2cat)	none^{R}	one co-morbidity	greater than one co-morbidity			
excellent, very good, good^{R}	2,569.00 (91.33%) 110,842,654.41 (93.75%)	235.00 (77.56%) 10,845,849.86 (82.50%)	36.00 (64.29%) 2,316,740.82 (74.78%)		94.11 *<0.0001*	7.01 *0.0023*
fair, poor	244.00 (8.67%) 7,383,458.27 (6.25%)	68.00 (22.44%) 2,300,883.45 (17.50%)	* (0.00%) 781,537.87 (25.22%)			
	Treatment for Iron Deficiency past 3 months (FeTx2cat)					
Iron Deficiency (FeD2cat)	yes	no^{R}				
within normal limits^{R}	115.00 (67.25%) 3,380,480.87 (65.69%)	2,608.00 (86.90%) 119,442,698.68 (92.35%)			51.42 *<0.0001*	4.17 *0.047*
iron deficient	56.00 (32.75%) 1,765,815.10 (34.31%)	393.00 (13.10%) 9,899,459.71 (7.65%)				
	Source of Healthcare (hcsre)					
Health Insurance (hi2cat)	healthcare provider^{R}	clinic	ER or none	missing		
private^{R}	1,408.00 (77.92%) 70,148,220.11 (82.37%)	356.00 (52.66%) 15,925,109.07 (67.00%)	244.00 (38.01%) 11,763,693.79 (51.23%)	34.00 (70.83%) 2,295,755.50 (87.98%)		
public	207.00 (11.46%) 5,828,476.81 (6.84%)	136.00 (20.12%) 2,523,657.15 (10.62%)	92.00 (14.33%) 1,377,137.24 (6.00%)	* (0.00%) 62,148.88 (2.38%)	504.59 *<0.0001*	6.45 *0.0000*
none	150.00 (8.30%) 7,084,647.84 (8.32%)	179.00 (26.48%) 5,188,183.59 (21.83%)	281.00 (43.77%) 9,244,055.24 (40.26%)	* (0.00%) 245,917.70 (9.42%)		
missing	42.00 (2.32%) 2,100,495.24 (2.47%)	* (0.00%) 131,147.07 (0.55%)	* (0.00%) 577,770.48 (2.52%)	* (0.00%) 5,617.72 (0.22%)		

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value unweighted*	χ^2 *p value weighted*
	Regular Source of Healthcare (hp2cat)					
Source of Healthcare (hcsre)	yes^{R}	no				
healthcare provider^{R}	1,807.00 (67.60%) 85,161,840.00 (73.76%)	0.00 (0.00%) 0.00 (0.00%)			2,339.90 *<0.0001*	11.42 *0.0000*
clinic	676.00 (25.29%) 23,768,096.88 (20.59%)	0.00 (0.00%) 0.00 (0.00%)				
ER or none	142.00 (5.31%) 3,918,905.64 (3.39%)	500.00 (100.00%) 19,043,751.11 (100.00%)				
missing	48.00 (1.80%) 2,609,439.81 (2.26%)	0.00 (0.00%) 0.00 (0.00%)				
	Body Mass Index (bmi30cat)					
Food Security (food2cat)	<30.0^{R} underweight normal overweight	30.0+ obese	missing			
food secure^{R}	1,941.00 (82.35%) 89,256,111.99 (86.79%)	597.00 (76.83%) 23,497,629.27 (77.76%)	34.00 (87.18%) 1,290,171.40 (89.49%)		15.44 *0.004*	2.49 *0.056*
food insecure	310.00 (13.15%) 8,787,220.12 (8.54%)	145.00 (18.66%) 5,376,408.10 (17.79%)	* (0.00%) 70,893.83 (4.92%)			
missing	106.00 (4.50%) 4,800,564.81 (4.67%)	35.00 (4.50%) 1,342,420.43 (4.44%)	* (0.00%) 80,613.48 (5.59%)			
	Fat Intake/AMDR (fat3cat)					
Food Security (food2cat)	recommended or less^{R}	more than recommended				
food secure^{R}	1,513.00 (79.72%) 67,837,817.09 (83.60%)	1,059.00 (83.065%) 46206095.57 (86.60%)			5.70 *0.058*	0.81 *0.45*
food insecure	296.00 (15.60%) 9,215,828.85 (11.36%)	163.00 (12.78%) 5018693.20 (9.41%)				
missing	89.00 (4.69%) 4,090,696.09 (5.04%)	53.00 (4.16%) 2,132,902.62 (3.99%)				

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
	U.S. Poverty Threshold (pov2cat)					
Food Security (food2cat)	more than 1.00^{R}	1.00 or less	missing			
food secure^{R}	1,932.00 (86.25%) 91,382,474.30 (87.91%)	489.00 (66.99%) 17,025,611.13 (75.33%)	151.00 (69.91%) 5,635,827.23 (70.79%)		390.73 *<0.0001*	8.42 *0.0000*
food insecure	206.00 (9.25%) 8,765,266.27 (8.43%)	234.00 (32.05%) 5,182,943.35 (22.95%)	* (0.00%) 286,312.42 (3.60%)			
missing	46.00 (21.30%) 2,039,073.12 (25.61%)	89.00 (4.00%) 3,805,882.62 (3.66%)	7.00 (0.96%) 378,642.99 (1.68%)			
	Fat Intake/AMDR (fat3cat)					
Body Mass Index (bmi30cat)	recommended or less^{R}	more than recommended				
<30.0^{R} underweight, normal, overweight	1,440.00 (75.87%) 63,977,815.31 (78.84%)	917.00 (71.92%) 38,866,081.61 (72.84%)			11.88 *0.0026*	2.08 *0.137*
30.0+ obese	429.00 (22.60%) 16,145,112.74 (19.89%)	348.00 (27.29%) 14,071,345.06 (26.37%)				
missing	29.00 (1.27%) 1,021,413.99 (1.26%)	10.00 (0.79%) 420,264.71 (0.79%)				
	Live Births (live)					
Body Mass Index (bmi30cat)	no live births^{R}	one or more live births				
<30.0^{R} underweight, normal, overweight	1,481.00 (81.37%) 55,529,169.26 (82.36%)	876.00 (64.75%) 47,314,727.66 (70.53%)			112.69 *<0.0001*	3.57 *0.0365*
30.0+ obese	321.00 (17.64%) 11,163,737.15 (16.56%)	456.00 (33.70%) 19,052,720.65 (28.40%)				
missing	18.00 (0.99%) 727,331.80 (1.08%)	21.00 (1.55%) 714,346.91 (1.06%)				
	Ever Breastfed (brstfda)					
Body Mass Index (bmi30cat)	never breastfed^{R}	breastfed more than one month				
<30.0^{R} underweight, normal, overweight	1,784.00 (76.80%) 71,780,209.53 (78.06%)	573.00 (67.41%) 31,063,687.39 (73.01%)			29.38 *<0.0001*	3.36 *0.0439*
30.0+ obese	511.00 (22.00%) 18,884,776.92 (20.54%)	266.00 (31.29%) 11,331,680.88 (26.63%)				
missing	28.00 (1.21%) 1,289,335.85 (1.40%)	11.00 (1.29%) 152,342.86 (0.36%)				

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
	Seafood Meals (smpw2cat)					
Protein Intake/AMDR (prot3cat)	none^{R}	any				
recommended or more^{R}	598.00 (87.17%) 19,990,155.11 (87.40%)	2,114.00 (85.00%) 98,773,610.16 (88.48%)			2.04 *0.153*	0.07 *0.792*
less than recommended	88.00 (12.83%) 2,880,685.67 (12.60%)	373.00 (15.00%) 12,857,582.49 (11.52%)				
	Seafood Meals (smpw2cat)					
Selenium Intake/RDA (sele2cat)	none^{R}	any				
recommended or more^{R}	528.00 (76.97%) 17,412,417.38 (76.13%)	2,031.00 (81.66) 95,266,065.47 (85.34%)			7.60 *0.0058*	3.86 *0.056*
less than recommended	158.00 (23.03%) 5,458,423.40 (23.87%)	456.00 (18.34%) 16,365,127.18 (14.66%)				
	Trimester of Pregnancy (tripcorr)					
Current Pregnancy (pregnant)	not pregnant^{R}	1st trimester	2nd trimester	3rd trimester		
pregnant $n_{unweighted}$ = 391 $n_{weighted}$ = 4,842,189.09	0.00 (0.00%) 0.00 (0.00%)	149.00 (99.33%) 1,991,566.11 (100.00%)	132.00 (100.00%) 1,523,495.53 (100.00%)	110.00 (100.00%) 1,327,127.44 (100.00%)	3,173.00 *<0.0001*	16.06 *0.0000*
not pregnant^{R}	2,641.00 (94.93%) 1,26376,518.94 (93.96%)	0.00 (0.00%) 0.00 (0.00%)	0.00 (0.00%) 0.00 (0.00%)	0.00 (0.00%) 0.00 (0.00%)		
missing	141.00 (5.07%) 3,283,325.41 (2.44%)	0.00 (0.00%) 0.00 (0.00%)	0.00 (0.00%) 0.00 (0.00%)	0.00 (0.00%) 0.00 (0.00%)		
	Live Births (live)					
Ever Pregnant (tprg2cat)	no live births^{R}	one or more live births				
never pregnant^{R}	1,535.00 (84.34%) 59,565,096.98 (88.35%)	0.00 (0.00%) 0.00 (0.00%)			2,210.50 *<0.0001*	182.17 *0.0000*
one or more pregnancies	285.00 (15.66%) 7,855,141.24 (11.65%)	1,353.00 (100.00%) 67,081,795.22 (100.00%)				

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
	Ever Breastfed (brstfda)					
Live Births (live)	never breastfed^{R}	breastfed more than one month or currently				
no live births^{R}	1,820.00 (78.35%) 67,420,238.21 (50.13%)	0.00 (0.00%) 0.00 (0.00%)			1561.76 *<0.0001*	130.73 *0.0000*
one or more live births	503.00 (21.65%) 24,534,084.08 (26.68%)	850.00 (100.00%) 42,547,711.13 (100.00%)				
	Language Spoken at Home (lang2cat)					
Years in U.S. (yrus5)	English^{R}	Other				
born in U.S.^{R}	2,648.00 (93.14%) 119,574,469.41 (94.37%)	* (0.00%) 502,160.04 (6.79%)			1749.39 *<0.0001*	56.38 *0.0000*
five or more years	173.00 (6.09%) 6,274,037.58 (4.95%)	179.00 (55.59%) 4,799,481.63 (64.88%)				
less than five years	* (0.00%) 859,771.07 (0.68%)	120.00 (37.27%) 2,096,195.84 (28.34%)				
	U.S. Citizenship (usczn2cat)					
Years in U.S. (yrus5)	U.S. citizen^{R}	non-U.S. citizen				
born in U.S.^{R}	2,673.00 (95.06%) 120,303,696.80 (94.93%)	0.00 (0.00%) 0.00 (0.00%)			2277.87 *<0.0001*	37.43 *0.0000*
five or more years	133.00 (4.73%) 6,126,948.25 (4.83%)	219.00 (61.69%) 4,946,570.95 (64.99%)				
less than five years	* (0.00%) 291,572.56 (0.23%)	136.00 (38.31%) 2,664,394.36 (35.01%)				
	U.S. Citizenship (usczn2cat)					
Language Spoken at Home (lang2cat)	U.S. citizen^{R}	non-U.S. citizen				
English^{R}	2,734.00 (97.23%) 124,256,122.31 (98.15%)	110.00 (30.73%) 2,505,072.05 (32.73%)			1522.13 *<0.0001*	77.39 *0.0000*
Other	78.00 (2.77%) 2,342,082.25 (1.85%)	248.00 (69.27%) 5,149,820.78 (67.27%)				

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30					χ^2 *p value unweighted*	χ^2 *p value weighted*
	Fish Eaten in Past 30 Days (fish2cat)					
Shellfish Eaten in Past 30 Days (shell2cat)	none[R]	any				
none[R]	686.00 (65.96%) 22,870,840.78 (62.13%)	871.00 (40.83%) 40,147,798.40 (41.10%)			176.62 *<0.0001*	11.03 *0.0018*
any	354.00 (34.04%) 13,938,898.89 (37.87%)	1,262.00 (59.17%) 57,544,495.36 (58.90%)				
	Fish Eaten in Past 30 Days (fish2cat)					
Seafood Eaten in Past 30 Days (smpw2cat)	none[R]	any				
none[R]	686.00 (65.9%) 22,870,840.78 (62.13%)	0.00 (0.00%) 0.00 (0.00%)			1795.05 *<0.0001*	110.57 *0.0000*
any	354.00 (34.04%) 13,938,898.89 (37.87%)	2,133.00 (100.00%) 97,692,293.76 (100.00%)				
	Shellfish Eaten in Past 30 Days (shell2cat)					
Seafood Eaten in Past 30 Days (smpw2cat)	none[R]	any				
none[R]	686.00 (44.06%) 22,870,840.78 (36.29%)	0.00 (0.00%) 0.00 (0.00%)			908.39 *<0.0001*	92.67 *0.0000*
any	871.00 (55.94%) 40,147,798.40 (63.71%)	1,616.00 (100.00%) 71,483,394.25 (100.00%)				
	Tap Water Source (h2os2cat)					
Tap Water Consumed past 24h (tap2kct)	public[R]	private	missing			
none[R]	975.00 (34.50%) 33,223,428.63 (28.46%)	113.00 (42.48%) 6,025,957.02 (41.58%)	41.00 (50.62%) 1,255,442.59 (38.34%)			
< 2,000 ml	1,390.00 (49.19%) 63,041,240.20 (54.00%)	122.00 (45.86%) 6,595,092.42 (45.51%)	* (0.00%) 1,409,152.80 (43.03%)		23.57 *0.0006*	4.03 *0.0026*
2,000+ ml	263.00 (9.31%) 13,414,568.57 (11.49%)	* (0.00%) 1,701,154.02 (11.74%)	* (0.00%) 413,829.90 (12.64%)			
missing	198.00 (7.01%) 7,056,670.76 (6.04%)	* (0.00%) 169,331.56 (1.17%)	* (0.00%) 196,164.94 (5.99%)			

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30					χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
	Residential Tap Water Treatment (h2ox2cat)					
Tap Water Consumed past 24h (tap2kct)	yes	no[R]	missing			
none[R]	213.00 (24.68%) 8,657,607.21 (19.11%)	888.00 (39.66%) 30,854,229.99 (35.65%)	* (0.00%) 992,991.04 (37.49%)			
< 2,000 ml	522.00 (60.49%) 30,205,324.44 (66.67%)	981.00 (43.81%) 39,474,226.06 (45.61%)	35.00 (49.30%) 1,365,934.92 (51.57%)		89.81 *<0.0001*	5.50 *0.0003*
2,000+ ml	89.00 (10.31%) 4,986,577.49 (11.01%)	205.00 (9.16%) 10,521,106.33 (12.16%)	* (0.00%) 21,868.68 (0.83%)			
missing	39.00 (4.52%) 1,458,725.52 (3.22%)	165.00 (7.37%) 5,695,774.98 (6.58%)	7.00 (9.86%) 267,666.76 (10.11%)			
	Serum Cotinine (cot3cat)					
Alcohol Consumption (retohuse)	< 1.0 ng/ml[R]	1.0 - 10.0 ng/ml	> 10.0 ng/ml			
never, seldom drinker[R] *including 16-19 y/o*	1,362.00 (57.52%) 41,883,173.64 (42.36%)	130.00 (68.42%) 2,207,900.23 (42.05%)	245.00 (40.83%) 7,996,189.95			
drinker	581.00 (24.54%) 31,478,549.38 (31.84%)	* (0.00%) 1,642,802.71 (31.29%)	113.00 (18.83%) 7,057,861.37 (23.72%)		192.77 *<0.0001*	2.74 *0.024*
heavy drinker	312.00 (13.18%) 20,883,010.05 (21.12%)	* (0.00%) 1,199,798.28 (22.85%)	218.00 (36.33%) 13,682,571.10 (45.99%)			
missing	113.00 (4.77%) 4,626,740.51 (4.68%)	* (0.00%) 199,800.39 (3.81%)	* (0.00%) 1,013,718.81 (3.41%)			
	Environmental Tobacco Smoke (ETS)					
Serum Cotinine (cot3cat)	no ETS[R]	ETS at home or at work	ETS at home and at work			
< 1.0 ng/ml[R]	2,040.00 (84.93%) 87,163,820.06 (86.16%)	309.00 (47.54%) 10,705,253.64 (40.08%)	* (0.00%) 1,002,399.86 (16.71%)			
1.0 - 10.0 ng/ml	107.00 (4.45%) 2,124,105.13 (2.10%)	78.00 (12.00%) 3,055,931.78 (11.44%)	* (0.00%) 70,264.71 (1.17%)		628.17 *<0.0001*	23.15 *0.0000*
> 10.0 ng/ml	255.00 (10.62%) 11,879,529.38 (11.74%)	263.00 (40.46%) 12945684.18 (48.47%)	82.00 (77.36%) 4,925,127.68 (82.12%)			

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
	Self-Reported Tobacco Use (tobuse)					
Serum Cotinine (cot3cat)	age restricted^{R}	never	former	current		
< 1.0 ng/ml^{R}	830.00 (75.39%) 13,874,581.99 (74.01%)	1,248.00 (94.19%) 68,473,062.62 (94.76%)	257.00 (86.53%) 14,629,369.30 (88.96%)	33.00 (7.59%) 1,894,459.64 (7.17%)		
1.0 - 10.0 ng/ml	100.00 (9.08%) 1,221,535.37 (6.52%)	56.00 (4.23%) 2,615,754.04 (3.62%)	* (0.00%) 461,855.17 (2.81%)	* (0.00%) 951,157.01 (3.60%)	1,724.60 *<0.0001*	21.59 *0.0000*
> 10.0 ng/ml	171.00 (15.53%) 3,649,817.08 (19.47%)	* (0.00%) 1,171,855.77 (1.62%)	* (0.00%) 1,354,453.22 (8.24%)	387.00 (88.97%) 23,574,215.16 (89.23%)		
	Residential Tap Water Treatment (h2ox2cat)					
Tap Water Source (h2os2cat)	yes	no^{R}	missing			
public^{R}	706.00 (81.81%) 37,562,745.23 (82.90%)	2,097.00 (93.66%) 78,629,947.58 (90.85%)	* (0.00%) 543,215.36 (20.51%)		1,314.81 *<0.0001*	3.06 *0.026*
private	153.00 (17.73%) 7,422,870.19 (16.38%)	112.00 (5.00%) 6,989,566.08 (8.08%)	* (0.00%) 79,098.75 (2.99%)			
missing	* (0.00%) 322,619.25 (0.71%)	30.00 (1.34%) 925,823.70 (1.07%)	47.00 (66.20%) 2,026,147.29 (76.50%)			
	Resident Status (resd3cat)					
Type of Residence (res3cat)	own^{R}	rent	other *including missing*			
attached or detached house^{R}	1,548.00 (89.64%) 69,420,478.62 (89.86%)	476.00 (37.25%) 18,097,932.14 (35.37%)	48.00 (28.57%) 1,787,559.80 (29.36%)		1,291.91 *<0.0001*	24.07 *0.0000*
mobile home or trailer	143.00 (8.28%) 6,233,638.41 (8.07%)	50.00 (3.91%) 1,873,766.07 (3.66%)	* (0.00%) 294,373.32 (4.84%)			
all other types *including missing/unknown*	36.00 (2.08%) 1,596,190.10 (2.07%)	752.00 (58.84%) 31,192,197.36 (60.97%)	111.00 (66.07%) 4,005,897.61 (65.80%)			
	Resident Status (resd3cat)					
Age of Residence (resb60cat)	own^{R}	rent	other *including missing*			
1960 or newer^{R}	1,138.00 (65.89%) 55,261,058.05 (71.54%)	410.00 (32.08%) 21,314,206.66 (41.66%)	47.00 (27.98%) 1,469,259.30 (24.13%)		651.29 *<0.0001*	21.57 *0.0000*
older than 1960	449.00 (26.00%) 18,303,204.02 (23.69%)	265.00 (20.74%) 11,664,723.07 (22.80%)	52.00 (30.95%) 2,124,273.01 (34.89%)			
missing/unknown	140.00 (8.11%) 3,686,045.05 (4.77%)	603.00 (47.18%) 18,184,965.84 (35.54%)	69.00 (41.07%) 2,494,298.42 (40.97%)			

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30					χ^2 *p value unweighted*	χ^2 *p value weighted*
	Resident Status (resd3cat)					
Years at Current Residence (re5yrcat)	own[R]	rent	other *including missing*			
more than five years[R]	897.00 (51.94%) 39,199,292.03 (50.74%)	189.00 (14.79%) 6,094,286.85 (11.91%)	* (0.00%) 600,739.80 (9.87%)		1,342.88 *<0.0001*	25.54 *0.0000*
five years or less	830.00 (48.06%) 38,051,015.10 (49.26%)	1,087.00 (85.05%) 45,001,738.00 (87.96%)	90.00 (53.57%) 3,402,859.84 (55.90%)			
missing	0.00 (0.00%) 0.00 (0.00%)	* (0.00%) 67,870.72 (0.13%)	51.00 (30.36%) 2,084,231.09 (34.24%)			
	Rooms in Residence (rm3cat)					
Household Size (hsize)	7+ rooms[R]	4-6 rooms	1-3 rooms	missing		
four persons or less[R]	683.00 (59.49%) 36,468,109.07 (69.31%)	1207.00 (71.38%) 58,206,284.87 (84.23%)	233.00 (88.59%) 9,435,232.73 (92.73%)	59.00 (83.10%) 2,344,401.71 (89.82%)	106.24 *<0.0001*	7.96 *0.0002*
more than four persons	465.00 (40.51%) 16,148,403.74 (30.69%)	484.00 (28.62%) 10,893,847.72 (15.77%)	30.00 (11.41%) 739,940.38 (7.27%)	* (0.00%) 265,813.21 (10.18%)		
	Time in Current Employment (cjt)					
Current Occupation (cocc2cat)	not working[R]	less than five years	five or more years			
not working[R]	1,324.00 (100.00%) 42,172,957.57 (100.00%)	0.00 (0.00%) 0.00 (0.00%)	0.00 (0.00%) 0.00 (0.00%)		3194.79 *<0.0001*	59.82 *0.0000*
management, professional & sales	0.00 (0.00%) 0.00 (0.00%)	934.00 (65.13%) 47,316,425.78 (70.37%)	309.00 (74.46%) 20,442,465.96 (81.48%)			
services & goods	0.00 (0.00%) 0.00 (0.00%)	500.00 (34.87%) 19,925,213.95 (29.63%)	106.00 (25.54%) 4,644,970.16 (18.52%)			
	Total Hours Worked Prior Week (hrwk)					
Current Occupation (cocc2cat)	not worked[R]	less than 35 hours	35+ hours			
not working[R]	1,323.00 (95.80%) 42,151,088.89 (92.02%)	0.00 (0.00%) 0.00 (0.00%)	0.00 (0.00%) 0.00 (0.00%)		2959.42 *<0.0001*	57.79 *0.0000*
management, professional & sales	58.00 (4.20%) 3,656,949.14 (7.98%)	460.00 (62.50%) 21,926,910.36 (65.71%)	725.00 (68.79%) 42,175,032.24 (76.43%)			
services & goods	0.00 (0.00%) 0.00 (0.00%)	276.00 (37.50%) 11,440,523.43 (34.29%)	329.00 (31.21%) 13,006,488.77 (23.57%)			

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value unweighted*	χ^2 *p value weighted*
	Time in Longest Employment (ljt)					
Longest Held Occupation (locc2cat)	not applicable^{R}	less than five years	five or more years			
not applicable^{R}	1,562.00 (100.00%) 64,117,356.51 (100.00%)	0.00 (0.00%) 0.00 (0.00%)	0.00 (0.00%) 0.00 (0.00%)		3191.73 *<0.0001*	92.59 *0.0000*
management, professional & sales	0.00 (0.00%) 0.00 (0.00%)	529.00 (53.06%) 19,500,975.82 (56.46%)	374.00 (60.91%) 21,914,210.33 (61.14%)			
services & goods	0.00 (0.00%) 0.00 (0.00%)	468.00 (46.94%) 1,504,1293.03 (43.54%)	240.00 (39.09%) 13,928,197.74 (38.86%)			
	Current Occupation (cocc2cat)					
Work History (wkcp)	not working^{R}	management, professional & sales	services & goods			
never employed^{R}	408.00 (30.82%) 8,238,810.80 (19.54%)	0.00 (0.00%) 0.00 (0.00%)	0.00 (0.00%) 0.00 (0.00%)			
currently employed	0.00 (0.00%) 0.00 (0.00%)	804.00 (64.68%) 42,694,958.49 (63.01%)	350.00 (57.76%) 13,183,587.23 (53.66%)		3187.29 *<0.0001*	44.91 *0.0000*
employed in the past but not currently	916.00 (69.18%) 33,934,146.78 (80.46%)	0.00 (0.00%) 0.00 (0.00%)	0.00 (0.00%) 0.00 (0.00%)			
employed now and in the past	0.00 (0.00%) 0.00 (0.00%)	439.00 (35.32%) 25,063,933.25 (36.99%)	256.00 (42.24%) 11,386,596.89 (46.34%)			
	Longest Held Occupation (locc2cat)					
Work History (wkcp)	not applicable^{R}	management, professional & sales	services & goods			
never employed^{R}	408.00 (26.12%) 8,238,810.80 (12.85%)	0.00 (0.00%) 0.00 (0.00%)	0.00 (0.00%) 0.00 (0.00%)			
currently employed	1,154.00 (73.88%) 55,878,545.72 (87.15%)	0.00 (0.00%) 0.00 (0.00%)	0.00 (0.00%) 0.00 (0.00%)		3,173.13 *<0.0001*	65.91 *0.0000*
employed in the past but not currently	0.00 (0.00%) 0.00 (0.00%)	516.00 (57.14%) 21,792,025.47 (52.62%)	400.00 (56.50%) 12,142,121.30 (41.91%)			
employed now and in the past	0.00 (0.00%) 0.00 (0.00%)	387.00 (42.86%) 19,623,160.67 (47.38%)	308.00 (43.50%) 16,827,369.47 (58.09%)			

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
	Employment Status (emp3cat)					
Highest Education (educ2)	employed	not employed^{R}				
high school diploma, GED or higher^{R}	1,428.00 (77.06%) 79,230,888.20 (85.68%)	609.00 (46.24%) 27,676,273.14 (65.97%)			318.45 *<0.0001*	32.44 *0.0000*
less than high school diploma	425.00 (22.94%) 13,237,911.77 (14.32%)	708.00 (53.76%) 14,278,602.02 (34.03%)				
	Reason for Unemployment (unem2cat)					
Highest Education (educ2)	working^{R}	voluntary unemployment	involuntary unemployment	missing		
high school diploma, GED or higher^{R}	1,428.00 (77.06%) 79,230,888.20 (85.68%)	378.00 (40.91%) 17,810,827.03 (63.01%)	165.00 (56.12%) 6,863,476.19 (67.32%)	66.00 (65.35%) 3,001,969.92 (85.65%)	359.99 *<0.0001*	14.28 *0.0000*
less than high school diploma	425.00 (22.94%) 13,237,911.77 (14.32%)	546.00 (59.09%) 10,454,194.64 (36.99%)	129.00 (43.88%) 3,332,499.03 (32.68%)	35.00 (34.65%) 503,127.87 (14.35%)		
	Reason for Unemployment (unem2cat)					
Employment Status (emp3cat)	working^{R}	voluntary unemployment	involuntary unemployment	missing		
employed	1,853.00 (100.00%) 92,468,799.96 (100.00%)	0.00 (0.00%) 0.00 (0.00%)	0.00 (0.00%) 0.00 (0.00%)	0.00 (0.00%) 0.00 (0.00%)	3,171.00 *<0.0001*	69.89 *0.0000*
not employed^{R}	0.00 (0.00%) 0.00 (0.00%)	924.00 (100.00%) 28,265,021.67 (100.00%)	295.00 (100.00%) 10,263,114.01 (100.00%)	99.00 (100.00%) 3,493,878.27 (100.00%)		
	Marital Status (marr3cat)					
U.S. Poverty Threshold (pov2cat)	married or living with partner	widowed, divorced or separated	never married^{R}	missing		
more than 1.00^{R}	962.00 (80.30%) 53,319,206.48 (86.28%)	152.00 (58.24%) 9,842,029.42 (68.57%)	1,049.00 (64.08%) 36,871,187.98 (68.93%)	64.00 (83.12%) 3,921,199.31 (80.77%)	129.06 *<0.0001*	3.33 *0.0086*
1.00 or less	162.00 (13.52%) 5,800,026.31 (9.39%)	91.00 (34.87%) 3,840,416.45 (26.76%)	471.00 (28.77%) 12,750,736.01 (23.84%)	* (0.00%) 196,018.69 (4.04%)		
missing	74.00 (6.18%) 2,681,415.46 (4.34%)	* (0.00%) 671,506.51 (4.68%)	117.00 (7.15%) 3,871,027.49 (7.24%)	7.00 (9.09%) 737,263.30 (15.19%)		

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
	Highest Education (educ2)					
U.S. Poverty Threshold (pov2cat)	high school diploma, GED or higher^{R}	less than high school diploma				
more than 1.00^{R}	1,562.00 (76.68%) 87,575,534.18 (81.92%)	664.00 (58.50%) 16,310,950.22 (59.25%)			115.63 *<0.0001*	3.08 *0.056*
1.00 or less	362.00 (17.77%) 13,492,269.81 (12.62%)	368.00 (32.42%) 9,094,927.65 (33.04%)				
missing	113.00 (5.55%) 5,839,357.35 (5.46%)	103.00 (9.07%) 2,121,855.42 (7.71%)				
	Current Occupation (cocc2cat)					
U.S. Poverty Threshold (pov2cat)	not working^{R}	management, professional & sales	services & goods			
more than 1.00^{R}	754.00 (56.95%) 27,435,957.82 (65.06%)	1,061.00 (85.36%) 59,864,335.85 (88.35%)	412.00 (67.99%) 16,653,329.52 (67.78%)		255.96 *<0.0001*	12.27 *0.0000*
1.00 or less	455.00 (34.37%) 11,977,284.37 (28.40%)	125.00 (10.06%) 4,212,539.78 (6.22%)	150.00 (24.75%) 6,397,373.32 (26.04%)			
missing	115.00 (8.69%) 2,759,715.38 (6.54%)	57.00 (4.59%) 3,682,016.11 (5.43%)	44.00 (7.26%) 1,519,481.28 (6.18%)			
	Household Size (hsize)					
U.S. Poverty Threshold (pov2cat)	four persons or less^{R}	more than four persons				
more than 1.00^{R}	143.00 (6.55%) 6,871,248.02 (6.45%)	73.00 (7.37%) 1,089,964.75 (3.89%)			58.17 *<0.0001*	2.77 *0.074*
1.00 or less	1618.00 (74.15%) 83,822,831.95 (78.74%)	609.00 (61.45%) 20,130,791.24 (71.77%)				
missing	421.00 (19.29%) 15,759,948.42 (14.80%)	309.00 (31.18%) 6827249.05 (24.34%)				
	Reason for Unemployment (unem2cat)					
U.S. Poverty Threshold (pov2cat)	working^{R}	voluntary unemployment	involuntary unemployment	missing		
more than 1.00^{R}	1,476.00 (79.65%) 76,635,520.79 (82.88%)	536.00 (58.01%) 18,956,878.10 (67.07%)	147.00 (49.83%) 5,920,332.22 (57.69%)	68.00 (67.33%) 2,440,892.08 (69.64%)	211.91 *<0.0001*	3.40 *0.007*
1.00 or less	275.00 (14.84%) 10,609,913.10 (11.47%)	312.00 (33.77%) 7,475,095.63 (26.45%)	114.00 (38.64%) 3,526,666.48 (34.36%)	* (0.00%) 975,522.25 (27.83%)		
missing	102.00 (5.50%) 5,223,366.07 (5.65%)	76.00 (8.23%) 1,833,047.95 (6.49%)	34.00 (11.53%) 816,115.30 (7.95%)	4.00 (3.96%) 88,683.45 (2.53%)		

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value unweighted*	χ^2 *p value weighted*
	Highest Education (educ2)					
Race-Ethnicity (race5cat)	high school diploma, GED or higher^{R}	less than high school diploma				
Non-Hispanic White^{R}	1,173.00 (57.58%) 81,668,719.25 (76.39%)	320.00 (28.19%) 16,218,824.91 (58.92%)				
Non-Hispanic Black	349.00 (17.13%) 9,102,591.03 (8.51%)	274.00 (24.14%) 3,644,587.34 (13.24%)			327.27 *<0.0001*	8.13 *0.0001*
Mexican American	316.00 (15.51%) 4,617,923.82 (4.32%)	429.00 (37.80%) 4,052,651.98 (14.72%)				
Other Hispanic	94.00 (4.61%) 5,003,783.20 (4.68%)	83.00 (7.31%) 2,455,070.23 (8.92%)				
Asian, Native American, Pacific Islander & Multi-Racial	105.00 (5.15%) 6.514.144.04 (6.09%)	* (0.00%) 1,156,598.84 (4.20%)				
	Reason for Unemployment (unem2cat)					
Race-Ethnicity (race5cat)	working^{R}	voluntary unemployment	involuntary unemployment	missing		
Non-Hispanic White^{R}	990.00 (53.43%) 69,427,978.22 (75.08%)	341.00 (36.90%) 19,176,171.18 (67.84%)	125.00 (42.37%) 6,764,445.01 (65.91%)	37.00 (36.63%) 2,518,949.76 (71.87%)		
Non-Hispanic Black	319.00 (17.22%) 8,156,696.99 (8.82%)	176.00 (19.05%) 2,047,744.12 (7.24%)	94.00 (31.86%) 1,966,882.49 (19.16%)	34.00 (33.66%) 575,854.77 (16.43%)	152.76 *<0.0001*	6.17 *0.0000*
Mexican American	367.00 (19.81%) 4,764,599.82 (5.15%)	308.00 (33.33%) 3,138,379.77 (11.10%)	51.00 (17.29%) 495,733.47 (4.83%)	* (0.00%) 271,862.74 (7.76%)		
Other Hispanic	83.00 (4.48%) 4,176,772.64 (4.52%)	69.00 (7.47%) 2,648,536.68 (9.37%)	* (0.00%) 639,990.34 (6.24%)	* (0.00%) 60,692.55 (1.73%)		
Asian, Native American, Pacific Islander & Multi-Racial	94.00 (5.07%) 5,942,752.30 (6.43%)	30.00 (3.25%) 1,254,189.93 (4.44%)	* (0.00%) 396,062.70 (3.86%)	* (0.00%) 77,737.96 (2.22%)		

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value unweighted*	χ^2 *p value weighted*
	U.S. Poverty Threshold (pov2cat)					
Race-Ethnicity (race5cat)	more than 1.00^{R}	1.00 or less	missing			
Non-Hispanic White^{R}	1,179.00 (52.94%) 78,846,347.78 (75.85%)	231.00 (31.64%) 13,908,178.21 (61.58%)	83.00 (38.43%) 5,133,018.17 (64.48%)			
Non-Hispanic Black	363.00 (16.30%) 8,204,067.35 (7.89%)	205.00 (28.08%) 3,541,288.29 (15.68%)	55.00 (25.46%) 1,001,822.73 (12.58%)		117.68 *<0.0001*	2.26 *0.040*
Mexican American	481.00 (21.60%) 5,845,858.36 (5.62%)	211.00 (28.90%) 2,204,434.75 (9.76%)	53.00 (24.54%) 620,282.70 (7.79%)			
Other Hispanic	117.00 (5.25%) 5,034,661.04 (4.84%)	44.00 (6.03%) 1,630,523.78 (7.22%)	* (0.00%) 860,807.40 (10.81%)			
Asian, Native American, Pacific Islander & Multi-Racial	87.00 (3.91%) 6,022,688.67 (5.79%)	39.00 (5.34%) 1,302,772.44 (5.77%)	* (0.00%) 345,281.77 (4.34%)			
	Age (age4cat)					
Race-Ethnicity/Hispanic Grouping (race4cat)	16-19^{R}	20-29	30-39	40-49		
Non-Hispanic White^{R}	367.00 (33.82%) 2,396,253.18 (66.94%)	514.00 (58.14%) 5825897.52 (74.76%)	364.00 (51.85%) 2,950,223.53 (69.17%)	248.00 (49.40%) 3,574,174.26 (77.13%)		
Non-Hispanic Black	247.00 (22.76%) 1,714,116.00 (9.26%)	145.00 (16.40%) 3,746,815.73 (8.26%)	119.00 (16.95%) 3,760,796.13 (10.34%)	112.00 (22.31%) 3,525,450.50 (10.28%)	154.45 *<0.0001*	2.14 *0.0454*
Hispanic	430.00 (39.63%) 3,378,004.42 (18.25%)	193.00 (21.83%) 5,626,135.77 (12.41%)	176.00 (25.07%) 4,650,483.61 (12.79%)	124.00 (24.70%) 2,541,944.23 (7.41%)		
Asian, Native American, Pacific Islander & Multi-Racial	41.00 (3.78%) 1,027,208.52 (5.55%)	32.00 (3.62%) 2,071,845.43 (4.57%)	43.00 (6.13%) 2,796,130.81 (7.69%)	* (0.00%) 1,775,558.12 (5.18%)		
	Health Insurance (hi2cat)					
Race-Ethnicity/Hispanic Grouping (race4cat)	private^{R}	public	none	missing		
Non-Hispanic White^{R}	1,178.00 (57.69%) 78,720,618.81 (78.62%)	107.00 (24.37%) 4,273,726.43 (43.65%)	171.00 (27.63%) 12,766,445.38 (58.66%)	37.00 (50.68%) 2,126,753.55 (75.55%)		
Non-Hispanic Black	341.00 (16.70%) 7,770,696.56 (7.76%)	157.00 (35.76%) 2,391,338.58 (24.42%)	109.00 (17.61%) 2,356,978.10 (10.83%)	* (0.00%) 228,165.13 (8.12%)	379.04 *<0.0001*	14.58 *0.0000*
Hispanic	445.00 (21.79%) 8,321,761.47 (8.31%)	143.00 (32.57%) 2,264,254.21 (23.13%)	320.00 (51.70%) 5,257,453.41 (24.16%)	* (0.00%) 353,098.93 (12.54%)		
Asian, Native American, Pacific Islander & Multi-Racial	78.00 (3.82%) 5,319,701.64 (5.31%)	32.00 (7.30%) 862,100.86 (8.81%)	* (0.00%) 1,381,927.47 (6.35%)	* (0.00%) 107,012.90 (3.80%)		

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30					χ^2 *p value unweighted*	χ^2 *p value weighted*
	Food Security (food2cat)					
Race-Ethnicity/Hispanic Grouping (race4cat)	food secure[R]	food insecure	missing			
Non-Hispanic White[R]	1,301.00 (50.58%) 85,394,002.15 (74.88%)	121.00 (26.36%) 8,336,128.60 (58.56%)	71.00 (50.00%) 4,157,413.41 (66.80%)			
Non-Hispanic Black	479.00 (18.62%) 10,346,994.84 (9.07%)	124.00 (27.02%) 2,041,509.69 (14.34%)	* (0.00%) 358,673.84 (5.76%)		124.63 *<0.0001*	5.36 *0.0003*
Hispanic	684.00 (26.59%) 11,941,499.37 (10.47%)	203.00 (44.22%) 3,529,387.56 (24.79%)	36.00 (25.36%) 725,681.09 (11.66%)			
Asian, Native American, Pacific Islander & Multi-Racial	108.00 (4.21%) 6,361,416.29 (5.58%)	* (0.00%) 327,496.20 (2.30%)	* (0.00%) 981,830.38 (15.77%)			
	Body Mass Index (bmi30cat)					
Race-Ethnicity/Hispanic Grouping (race4cat)	<30.0[R] underweight normal overweight	30.0+ obese	missing			
Non-Hispanic White[R]	1,205.00 (51.13%) 78,241,008.88 (76.08%)	271.00 (34.88%) 18,701,542.56 (61.89%)	* (0.00%) 944,992.72 (65.55%)			
Non-Hispanic Black	374.00 (15.87%) 6,845,949.44 (6.66%)	238.00 (30.63%) 5,681,300.24 (%)	* (0.00%) 219,928.68 (15.26%)		109.52 *<0.0001*	6.29 *0.0001*
Hispanic	665.00 (28.21%) 11,319,384.11 (11.01%)	247.00 (31.79%) 4,600,426.61 (15.23%)	* (0.00%) 276,757.30 (19.19%)			
Asian, Native American, Pacific Islander & Multi-Racial	113.00 (4.79%) 6,437,554.49 (6.26%)	* (0.000%) 1,233,188.39 (4.08%)	0.00 (0.00%) 0.00 (0.00%)			
	Serum Cotinine (cot3cat)					
Race-Ethnicity/Hispanic Grouping (race4cat)	< 1.0 ng/ml[R]	1.0 - 10.0 ng/ml	> 10.0 ng/ml			
Non-Hispanic White[R]	1,094.00 (46.20%) 72,627,347.15 (73.46%)	51.00 (26.84%) 2,624,966.84 (49.99%)	343.00 (57.17%) 22,168,404.25 (74.52%)			
Non-Hispanic Black	413.00 (17.44%) 8,121,811.18 (8.21%)	74.00 (38.95%) 1,040,809.38 (%)	129.00 (21.50%) 3,435,662.74 (%)		121.11 *<0.0001*	5.07 *0.0005*
Hispanic	767.00 (32.39%) 13,036,768.80 (13.19%)	48.00 (25.26%) 885,077.90 (16.86%)	105.00 (17.50%) 2,260,525.28 (7.59%)			
Asian, Native American, Pacific Islander & Multi-Racial	94.00 (3.97%) 5,085,546.44 (5.14%)	* (0.00%) 699,447.48 (13.32%)	* (0.00%) 1,885,748.96 (6.34%)			
missing = 15						

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value unweighted*	χ^2 *p value weighted*
	Type of Residence (res3cat)					
Race-Ethnicity/Hispanic Grouping (race4cat)	attached or detached house^{R}	mobile home or trailer	all other types *including missing/unknown*			
Non-Hispanic White^{R}	1,016.00 (49.03%) 67,876,940.99 (76.00%)	102.00 (50.50%) 6,356,324.95 (75.65%)	375.00 (41.71%) 23654278.21 (64.29%)			
Non-Hispanic Black	404.00 (19.50%) 7,961,266.03 (8.92%)	* (0.00%) 562,549.01 (6.69%)	194.00 (21.58%) 4,223,363.33 (11.48%)		33.37 *<0.0001*	1.35 *0.257*
Hispanic	585.00 (28.23%) 9,340,713.89 (10.46%)	67.00 (33.17%) 1,024,914.57 (12.19%)	271.00 (30.14%) 5,830,939.55 (%)			
Asian, Native American, Pacific Islander & Multi-Racial	67.00 (3.23%) 4,127,049.64 (4.62%)	* (0.00%) 457,989.26 (5.45%)	59.00 (6.56%) 3,085,703.98 (8.39%)			
	Age of Residence (resb60cat)					
Race-Ethnicity/Hispanic Grouping (race4cat)	1960 or newer^{R}	older than 1960	missing or unknown			
Non-Hispanic White^{R}	885.00 (55.48%) 59,496,716.52 (76.23%)	407.00 (53.13%) 25,276,967.64 (78.76%)	201.00 (24.75%) 13,113,860.01 (53.82%)			
Non-Hispanic Black	256.00 (16.05%) 5,812,871.98 (7.45%)	128.00 (16.71%) 2,230,733.61 (6.95%)	239.00 (29.43%) 4,703,572.77 (19.30%)		246.39 *<0.0001*	5.96 *0.0001*
Hispanic	370.00 (23.20%) 7,654,076.36 (9.81%)	210.00 (27.42%) 3,681,581.81 (11.47%)	343.00 (42.25%) 4,860,909.85 (19.95%)			
Asian, Native American, Pacific Islander & Multi-Racial	84.00 (5.27%) 5,080,859.15 (6.51%)	* (0.00%) 902,917.05 (2.81%)	* (0.00%) 1,686,966.68 (6.92%)			
	Age of Residence (resb78cat)					
Race-Ethnicity/Hispanic Grouping (race4cat)	1978 or newer^{R}	older than 1978	missing or unknown			
Non-Hispanic White^{R}	630.00 (57.96%) 42,439,346.81 (76.62%)	662.00 (51.96%) 42,334,337.34 (77.32%)	201.00 (24.75%) 13,113,860.01 (53.82%)			
Non-Hispanic Black	166.00 (15.27%) 4,043,746.25 (7.30%)	218.00 (17.11%) 3,999,859.33 (7.31%)	239.00 (29.43%) 4,703,572.77 (19.30%)		243.57 *<0.0001*	6.63 *0.0000*
Hispanic	243.00 (22.36%) 5,493,448.81 (9.92%)	337.00 (26.45%) 5,842,209.36 (10.67%)	343.00 (42.25%) 4,860,909.85 (19.95%)			
Asian, Native American, Pacific Islander & Multi-Racial	48.00 (4.42%) 3,411,506.97 (6.16%)	57.00 (4.47%) 2,572,269.22 (4.69%)	* (0.00%) 1,686,966.68 (6.92%)			

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
	Resident Status (resd3cat)					
Race-Ethnicity/Hispanic Grouping (race4cat)	own^{R}	rent	other *including missing*			
Non-Hispanic White^{R}	927.00 (53.68%) 60,696,837.19 (78.57%)	464.00 (36.31%) 32,092,120.18 (62.72%)	102.00 (60.71%) 5,098,586.78 (83.75%)			
Non-Hispanic Black	262.00 (15.17%) 5,104,082.44 (6.61%)	341.00 (26.68%) 7,470,697.69 (14.60%)	* (0.00%) 172,398.23 (2.83%)		126.54 *<0.0001*	3.57 *0.006*
Hispanic	485.00 (28.08%) 8,125,715.77 (10.52%)	400.00 (31.30%) 7,461,604.12 (14.58%)	38.00 (22.63%) 609,248.13 (10.01%)			
Asian, Native American, Pacific Islander & Multi-Racial	53.00 (3.07%) 3,323,671.71 (4.30%)	73.00 (5.71%) 4,139,473.57 (8.09%)	* (0.00%) 207,597.59 (3.41%)			
	Total Hours Worked Prior Week (hrwk)					
Race-Ethnicity/Hispanic Grouping (race4cat)	not employed^{R}	less than 35 hours	35+ hours			
Non-Hispanic White^{R}	534.00 (38.67%) 30,936,387.14 (67.54%)	426.00 (57.88%) 27,636,151.10 (82.83%)	532.00 (50.47%) 39,191,833.99 (71.02%)			
Non-Hispanic Black	318.00 (23.03%) 5,066,780.38 (11.06%)	92.00 (12.50%) 1,595,025.75 (4.78%)	213.00 (20.21%) 6,085,372.23 (11.03%)			
Hispanic	482.00 (34.90%) 7,506,773.31 (16.39%)	188.00 (25.54%) 3,120,063.49 (9.35%)	252.00 (23.91%) 5,547,862.54 (10.05%)		103.63 *<0.0001*	5.76 *0.0002*
Asian, Native American, Pacific Islander & Multi-Racial	47.00 (35.07%) 2,298,097.19 (5.02%)	* (0.00%) 1,016,193.45 (3.04%)	57.00 (5.41%) 4,356,452.24 (7.89%)			
missing = 2						
	Marital Status (marr3cat)					
Race-Ethnicity/Hispanic Grouping (race4cat)	married or living with partner	widowed, divorced or	never married^{R}	missing		
Non-Hispanic White^{R}	685.00 (57.18%) 49,217,838.59 (79.64%)	103.00 (39.46%) 8,249,274.17 (57.47%)	671.00 (40.99%) 37,539,926.15 (70.18%)	34.00 (44.16%) 2,880,505.23 (59.34%)		
Non-Hispanic Black	130.00 (10.85%) 3,510,070.41 (5.68%)	72.00 (27.59%) 2,437,997.53 (16.98%)	408.00 (24.92%) 6,303,355.06 (11.78%)	* (0.00%) 495,755.36 (10.21%)	141.39 *<0.0001*	4.77 *0.0002*
Hispanic	337.00 (28.13%) 6,468,838.53 (10.47%)	67.00 (25.67%) 1,867,408.96 (13.01%)	498.00 (30.42%) 7,095,260.43 (13.26%)	* (0.00%) 765,060.08 (15.76%)		
Asian, Native American, Pacific Islander & Multi-Racial	46.00 (3.84%) 2,603,900.71 (4.21%)	* (0.00%) 1,799,271.71 (12.53%)	60.00 (3.67%) 2,554,409.84 (4.78%)	* (0.00%) 713,160.62 (14.69%)		

Table 27
Bivariate Analyses of Selected Independent Variable Pairs Among Childbearing-Aged Participants (unweighted and weighted data 1999-2004)

Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30					χ^2 *p value unweighted*	χ^2 *p value weighted*
	Highest Education (educ2)					
Race-Ethnicity/Hispanic Grouping (race4cat)	high school diploma, GED or higher^{R}	less than high school diploma				
Non-Hispanic White^{R}	1,173.00 (57.58%) 81,668,719.25 (76.39%)	320.00 (28.19%) 16,218,824.91 (58.92%)				
Non-Hispanic Black	349.00 (17.13%) 9,102,591.03 (8.51%)	274.00 (24.14%) 3,644,587.34 (13.24%)			320.16 *<0.0001*	7.34 *0.0004*
Hispanic	410.00 (20.13%) 9,621,707.02 (9.00%)	512.00 (45.11%) 6,507,722.21 (23.64%)				
Asian, Native American, Pacific Islander & Multi-Racial	105.00 (5.15%) 6.514.144.04 (6.09%)	* (0.00%) 1,156,598.84 (4.20%)				
	Reason for Unemployment (unem2cat)					
Race-Ethnicity/Hispanic Grouping (race4cat)	working^{R}	voluntary unemployment	involuntary unemployment	missing		
Non-Hispanic White^{R}	990.00 (53.43%) 69,427,978.22 (75.08%)	341.00 (36.90%) 19,176,171.18 (67.84%)	125.00 (42.37%) 6,764,445.01 (65.91%)	37.00 (36.63%) 2,518,949.76 (71.87%)		
Non-Hispanic Black	319.00 (17.22%) 8,156,696.99 (8.82%)	176.00 (19.05%) 2,047,744.12 (7.24%)	94.00 (31.86%) 1,966,882.49 (19.16%)	34.00 (33.66%) 575,854.77 (16.43%)	148.29 *<0.0001*	4.95 *0.0001*
Hispanic	450.00 (24.28%) 8,941,372.46 (9.67%)	377.00 (40.80%) 5,786,916.45 (20.47%)	68.00 (23.05%) 1,135,723.81 (11.07%)	28.00 (27.72%) 332,555.30 (9.49%)		
Asian, Native American, Pacific Islander & Multi-Racial	94.00 (5.07%) 5,942,752.30 (6.43%)	30.00 (3.25%) 1,254,189.93 (4.44%)	* (0.00%) 396,062.70 (3.86%)	* (0.00%) 77,737.96 (2.22%)		
	U.S. Poverty Threshold (pov2cat)					
Race-Ethnicity/Hispanic Grouping (race4cat)	more than 1.00^{R}	1.00 or less	missing			
Non-Hispanic White^{R}	1,179.00 (52.94%) 78,846,347.78 (75.85%)	231.00 (31.64%) 13,908,178.21 (61.58%)	83.00 (38.43%) 5,133,018.17 (64.48%)			
Non-Hispanic Black	363.00 (16.30%) 8,204,067.35 (7.89%)	205.00 (28.08%) 3,541,288.29 (15.68%)	55.00 (25.46%) 1,001,822.73 (12.58%)		115.59 *<0.0001*	2.63 *0.029*
Hispanic	598.00 (26.85%) 10,880,519.39 (10.47%)	255.00 (34.93%) 3,834,958.53 (16.98%)	70.00 (32.41%) 1,481,090.10 (18.60%)			
Asian, Native American, Pacific Islander & Multi-Racial	87.00 (3.91%) 6,022,688.67 (5.79%)	39.00 (5.34%) 1,302,772.44 (5.77%)	* (0.00%) 345,281.77 (4.34%)			

Table 28
Univariate Analyses of Xenobiotic Blood Levels Prior to Logarithmic Transformation (unweighted data[1] 1999 - 2004)

Childbearing-Aged Participants

Dependent Variable Components	Univariate Statistics (µg/dl)									Percentiles							
Specific Chemicals of Interest µg/dl sample (n)	Arithmetic Mean	Median	Mode	Arithmetic Standard Deviation	Skewness	Range	Minimum	Maximum	Variance	10th	25th	50th	75th	90th	95th	99th	>99th
Lead n = 3,173	1.13	0.90	0.70	1.01	7.18	23.70	0.20	23.90	1.03	0.5 527	0.6 841	0.9 1,649	1.3 2,476	1.9 2,877	2.6 3,021	4.6 3,144	3,173
Methylmercury n = 3,173	1.16	0.52	0.22	1.85	5.42	31.20	0.00	31.20	3.41	0.1 335	0.223 1,083	0.52 1,629	1.32 2,403	2.92 2,857	4.5 3,021	8.3 3,145	3,173
Sum of Lipid-Adjusted PCB Congeners n = 3,173	53.30	41.00	19.00	57.94	7.12	1,442.00	4.56	1,447.00	3,357.22	14.3 312	20.8 794	41 1,597	63 2,383	103.3 2,857	144.2 3,015	255.7 3,143	3,173

Pregnant Childbearing-Aged Participants

Dependent Variable Components	Univariate Statistics (µg/dl)									Percentiles							
Specific Chemicals of Interest µg/dl sample (n)	Arithmetic Mean	Median	Mode	Arithmetic Standard Deviation	Skewness	Range	Minimum	Maximum	Variance	10th	25th	50th	75th	90th	95th	99th	>99th
Lead	0.88	0.70	0.50	0.62	2.85	4.80	0.20	5.00	0.39	0.4 75	0.5 128	0.7 200	1.1 300	1.4 356	2 375	3.6 388	391
Methylmercury	1.06	0.42	0.22	1.71	3.38	11.80	0.00	11.80	2.92	0.1 41	0.2 106	0.42 206	1.1 295	2.82 356	4.7 373	9.2 388	391
Sum of Lipid-Adjusted PCB Congeners	39.96	31.80	47.80	34.58	4.35	372.00	4.60	377.20	1,196.00	13.2 47	20 99	31.8 200	47.8 296	70.06 352	93.2 373	222.8 388	391

[1] no missing data

Table 29

Prevalence Rates for Individual Xenobiotic Blood Levels for Childbearing-Aged Female Participants and Pregnant Childbearing-Aged Participants Prior to Logarithmic Transformation (unweighted data[1] 1999 - 2004)

	Childbearing-Aged Female Participants			Pregnant Childbearing-Aged Participants		
Specific Chemicals of Interest	Below Detection	At Detection[2]	Above Detection	Below Detection	At Detection[2]	Above Detection
Lead LBXBPB	1.9 per 100	2.2 per 100	95.9 per 100	5.1 per 100	3.1 per 100	91.8 per 100
Total Mercury LBXTHG	4.2 per 100	4.2 per 100	91.6 per 100	2.6 per 100	3.8 per 100	93.6 per 100
Inorganic Mercury LBXIHG	86.5 per 100	3.5 per 100	10.0 per 100	89.3 per 100	2.8 per 100	7.9 per 100
PCB 118 LBX118	39.7 per 100	NA	60.3 per 100	41.2 per 100	NA	58.8 per 100
PCB 138 LBX138	30.1 per 100	NA	69.9 per 100	32.7 per 100	NA	67.3 per 100
PCB 153 LBX153	26.6 per 100	NA	73.4 per 100	28.4 per 100	NA	71.6 per 100
PCB 180 LBX180	33.1 per 100	NA	66.9 per 100	37.6 per 100	NA	62.4 per 100
	Less Than Zero	Equal to Zero	Greater Than Zero	Less Than Zero	Equal to Zero	Greater Than Zero
MeHg (THg - IHg)	15 per 100	3.5 per 100	81.5 per 100	12.5 per 100	3.9 per 100	83.6 per 100

[1] with no missing data

[2] PCBs' Levels of Detection was sample-specific

NA = Not Available

Table 30
Univariate Analyses of Xenobiotic Blood Levels Post Logarithmic Transformation (unweighted and weighted data[1] 1999 - 2004)

Childbearing-Aged Females

Dependent Variable Components	Univariate Statistics (µg/dl)									Percentiles							
Sample unweighted weighted cumulative unweighted cumulative weighted	Geometric Mean	Median	Mode	Geometric Standard Deviation	Skewness	Range	Minimum	Maximum	Variance	10th	25th	50th	75th	90th	95th	99th	>99th
Lead	-0.08	-0.11	-0.36	0.60	0.36	4.78	-1.61	3.17	0.36	-0.7 236 8,677,332.81 236 8,677,332.81	-0.5 230 8,808,667.99 466 17,486,000.80	-0.1 905 37,256,412.64 1,371 54,742,413.33	0.3 1,044 50,936,423.22 2,415 105,678,836.66	0.6 401 16,271,954.52 2,816 121,950,791.18	1.0 125 5,231,194.99 2,941 127,181,986.17	1.5 142 4,232,471.45 3,083 131,414,457.62	90 3,087,575.82 3,173 134,502,033.43
Methylmercury	0.59	0.42	0.20	0.53	1.37	3.47	0.00	3.47	0.28	0.1 219 7,779,275.63 219 7,779,275.63	0.2 568 20,251,205.53 787 28,030,481.16	0.4 842 32,552,938.25 1,629 60,583,419.41	0.8 774 35,330,269.85 2,403 95,913,689.26	1.4 449 21,246,299.64 2,852 117,159,988.90	1.7 161 7,992,994.37 3,013 125,152,983.27	2.2 132 7,335,270.10 3,145 132,488,253.37	28 2,013,780.06 3,173 134,502,033.43
Sum of Lipid-Adjusted PCB Congeners	3.65	3.71	2.98	0.78	0.23	5.76	1.52	7.28	0.60	2.7 322 6,636,249.80 322 6,636,249.80	3.0 449 12,106,578.89 771 18,742,828.69	3.7 813 30,090,732.22 1,584 48,833,560.91	4.1 799 38,358,029.62 2,383 87,191,590.53	4.6 470 28,557,239.62 2,853 115,748,830.15	5.0 162 9,962,450.92 3,015 125,711,281.07	5.5 126 7,044,651.91 3,141 132,755,932.98	32 1,746,100.44 3,173 134,502,033.43

Pregnant Childbearing-Aged Females

Dependent Variable Components	Univariate Statistics (µg/dl)									Percentiles							
Sample unweighted weighted cumulative unweighted cumulative weighted	Geometric Mean	Median	Mode	Geometric Standard Deviation	Skewness	Range	Minimum	Maximum	Variance	10th	25th	50th	75th	90th	95th	99th	>99th
Lead	-0.31	-0.36	-0.69	0.60	0.10	3.22	-1.61	1.61	0.36	-0.9 12 87,634.48 12 87,634.48	-0.7 43 390,879.19 55 478,513.67	-0.4 84 1,079,815.88 139 1,558,329.55	0.1 141 1,937,996.05 280 3,496,325.60	0.3 41 360,736.20 321 3,857,061.80	0.7 34 405,690.39 355 4,262,752.19	1.3 13 145,829.38 368 4,408,581.57	23 433,607.51 391
Methylmercury	0.55	0.35	0.20	0.52	1.59	2.55	0.00	2.55	0.27	0.1 29 377,332.60 29 377,332.60	0.2 77 1,006,043.78 106 1,383,376.38	0.4 81 823,682.43 187 2,207,058.81	0.7 104 978,770.39 291 3,185,829.20	1.3 58 923,548.88 349 4,109,378.08	1.7 21 125,708.86 370 4,235,086.94	2.3 18 416,958.43 388 4,652,045.37	3 190,143.72 391 4,842,189.09
Sum of Lipid-Adjusted PCB Congeners	3.46	3.46	3.87	0.66	0.17	4.41	1.53	5.93	0.44	2.6 47 368,954.11 47 368,954.11	3.0 52 555,265.47 99 924,219.58	3.5 101 1,189,387.49 200 2,113,607.07	3.9 96 973,056.76 296 3,086,663.83	4.2 56 1,011,276.31 352 4,097,940.14	4.5 21 328,088.20 373 4,426,028.34	5.4 15 394,968.28 388 4,820,996.62	3 21,192.47 391 4,842,189.09

[1] no missing data

Table 31
Prevalence Rates for Individual Xenobiotic Blood Levels for Childbearing-Aged Females and Pregnant Childbearing-Aged Females
(unweighted[1] and weighted data 1999 - 2004)

Sample Population (unweighted)

	Childbearing-Aged Female Participants			Pregnant Childbearing-Aged Participants		
Specific Chemicals of Interest	Below Geometric Mean		At or Above Geometric Mean	Below Geometric Mean		At or Above Geometric Mean
Lead LBXBPB	51.97 per 100		48.03 per 100	66.49 per 100		33.51 per 100
MeHg (THg - IHg)	60.23 per 100		39.77 per 100	67.01 per 100		32.99 per 100
PCBs (sumPCBla)	47.05 per 100		52.95 per 100	60.11 per 100		39.89 per 100

Study Population (weighted)

	Childbearing-Aged Females			Pregnant Childbearing-Aged Females		
Specific Chemicals of Interest	Below Geometric Mean		At or Above Geometric Mean	Below Geometric Mean		At or Above Geometric Mean
Lead LBXBPB	50.95 per 100		49.05 per 100	74.81 per 100		25.19 per 100
MeHg (THg - IHg)	52.55 per 100		47.45 per 100	59.42 per 100		32.99 per 100
PCBs (sumPCBla)	33.46 per 100		66.54 per 100	50.15 per 100		49.85 per 100

[1] with no missing data

Table 34
Exposure as Outcome in Four Categories: Number of Childbearing-Aged Females with Xenobiotic Blood Levels Below, At or Above the Geometric Mean
(unweighted and weighted data 1999-2004)

Dependent Variable Components Specific Chemicals of Interest Sample Frequency $_{unweighted}$ Col. Pct. Population Estimated Frequency $_{weighted}$ Col. Pct.	0	1	2	3	Total	χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
Lead							
Below Geometric Mean $_{unweighted}$	702.00 (100.00%)	600.00 (61.79%)	347.00 (34.53%)	0.00 (0.00%)	1,649.00 (51.97%)		
Below Geometric Mean $_{weighted}$	20,889,388.72 (100.00%)	25,299,379.85 (71.92%)	22,339,886.83 (43.63%)	0.00 (0.00%)	68,528,655.40 (50.95%)	1,344.41 *<0.0001*	49.30 *0.0000*
At or Above Geometric Mean $_{unweighted}$	0.00 (0.00%)	371.00 (38.21%)	658.00 (65.47%)	495.00 (100.00%)	1,524.00 (48.03%)		
At or Above Geometric Mean $_{weighted}$	0.00 (0.00%)	9,875,692.09 (28.08%)	28,865,899.17 (56.37%)	27,231,786.77 (100.00%)	65,973,378.03 (49.05%)		
Methylmercury							
Below Geometric Mean $_{unweighted}$	702.00 (100.00%)	742.00 (76.42%)	467.00 (46.47%)	0.00 (0.00%)	1,911.00 (60.23%)		
Below Geometric Mean $_{weighted}$	20,889,388.72 (100.00%)	27,957,025.03 (79.48%)	21,838,880.31 (42.65%)	0.00 (0.00%)	70,685,294.07 (52.55%)	1,398.82 <0.0001	75.63 *0.0000*
At or Above Geometric Mean $_{unweighted}$	0.00 (0.00%)	229.00 (23.58%)	538.00 (53.53%)	495.00 (100.00%)	1,262.00 (39.77%)		
At or Above Geometric Mean $_{weighted}$	0.00 (0.00%)	7,218,046.91 (20.52%)	29,366,905.69 (57.35%)	27,231,786.77 (100.00%)	63,816,739.36 (47.45%)		
Sum of PCBs							
Below Geometric Mean $_{unweighted}$	702.00 (100.00%)	600.00 (61.79%)	191.00 (19.00%)	0.00 (0.00%)	1,493.00 (47.05%)		
Below Geometric Mean $_{weighted}$	20,889,388.72 (100.00%)	17,093739.00 (48.60%)	7,027,018.85 (13.72%)	0.00 (0.00%)	45,010,146.57 (33.46%)	1,631.85 *<0.0001*	35.44 *0.0000*
At or Above Geometric Mean $_{unweighted}$	0.00 (0.00%)	371.00 (38.21%)	814.00 (81.00%)	495.00 (100.00%)	1,680.00 (52.95%)		
At or Above Geometric Mean $_{weighted}$	0.00 (0.00%)	18,081,332.94 (51.40%)	44,178,767.15 (86.28%)	27,231,786.77 (100.00%)	89,491,886.86 (66.54%)		

0 = all blood levels of lead, methylmercury and PCBs are below geometric mean (GM)
1 = one blood level is at or above geometric mean and two are below the geometric mean
2 = two blood levels are at or above geometric mean and one blood level is below geometric mean
3 = all blood levels of lead, methylmercury and PCBs are at or above geometric mean

Table 35

Exposure as Outcome in Four Categories: Number of Pregnant Childbearing-Aged Females with Xenobiotic Blood Levels Below, At or Above the Geometric Mean (unweighted and weighted data 1999-2004)

Total Number of Chemicals At or Above Geometric Mean Sample Frequency $_{unweighted}$ Col. Pct. Population Estimated Frequency $_{weighted}$ Col. Pct. * = cell size < 30	0	1	2	3	Total	χ^2 *p value unweighted*	χ^2 *p value weighted*
Lead							
Below Geometric Mean $_{unweighted}$	137.00	67.00	56.00	0.00	260.00		
	(100.00%)	(56.78%)	(50.91%)	(0.00%)	(66.49%)		
Below Geometric Mean $_{weighted}$	1,575,513.12	753,583.23	1,292,921.09	0.00	3,622,017.44		
	(100.00%)	(61.21%)	(74.38%)	(0.00%)	(74.80%)	137.63	10.27
At or Above Geometric Mean $_{unweighted}$	0.00	51.00	54.00	*	131.00	*<0.0001*	*0.0000*
	(0.00%)	(43.22%)	(49.09%)	(100.00%)	(33.51%)		
At or Above Geometric Mean $_{weighted}$	0.00	477,587.57	445,452.07	297,132.00	1,220,171.64		
	(0.00%)	(38.79%)	(25.62%)	(100.00%)	(25.20%)		
Methylmercury							
Below Geometric Mean $_{unweighted}$	137.00	85.00	40.00	0.00	262.00		
	(100.00%)	(72.03%)	(36.36%)	(0.00%)	(67.00%)		
Below Geometric Mean $_{weighted}$	1,575,513.12	991,992.10	309,519.74	0.00	2,877,024.96		
	(100.00%)	(80.57%)	(17.81%)	(0.00%)	(59.42%)	168.33	10.66
At or Above Geometric Mean $_{unweighted}$	0.00	33.00	70.00	*	129.00	*<0.0001*	*0.0000*
	(0.00%)	(27.97%)	(63.64%)	(100.00%)	(33.00%)		
At or Above Geometric Mean $_{weighted}$	0.00	239,178.70	1,428,853.42	297,132.00	1,965,164.12		
	(0.00%)	(19.43%)	(82.19%)	(100.00%)	(40.58%)		
Sum of PCBs							
Below Geometric Mean $_{unweighted}$	137.00	84.00	*	0.00	235.00		
	(100.00%)	(71.19%)	(0.00%)	(0.00%)	(60.10%)		
Below Geometric Mean $_{weighted}$	1,575,513.12	716,766.28	135,932.33	0.00	2,428,211.73		
	(100.00%)	(58.22%)	(7.82%)	(0.00%)	(50.15%)	239.11	13.53
At or Above Geometric Mean $_{unweighted}$	0.00	34.00	96.00	*	156.00	*<0.0001*	*0.0000*
	(0.00%)	(28.81%)	(87.27%)	(100.00%)	(39.90%)		
At or Above Geometric Mean $_{weighted}$	0.00	514,404.53	1,602,440.84	297,132.00	2,413,977.37		
	(0.00%)	(41.78%)	(92.18%)	(100.00%)	(49.85%)		

0 or 1 = all blood levels of lead, methylmercury and PCBs are below geometric mean OR one blood level is at or above geometric mean and two blood levels are below geometric mean

2 or 3 = two blood levels are at or above geometric mean and one blood level is below geometric mean OR all blood levels of lead, methylmercury and PCBs are at or above geometric mean

Table 36

Exposure as Outcome in Two Categories: Number of Childbearing-Aged Females with Xenobiotic Blood Levels Below, At or Above the Geometric Mean

(unweighted and weighted data 1999-2004)

Dependent Variable Components Specific Chemicals of Interest Sample Frequency $_{unweighted}$ Col. Pct. Population Estimated Frequency $_{weighted}$ Col. Pct.	0 and 1		2 and 3		Total	χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
Lead							
Below Geometric Mean $_{unweighted}$	1,302.00 (77.82%)		347.00 (23.13%)		1,649.00 (51.97%)	947.72 *<0.0001*	101.39 *0.0000*
Below Geometric Mean $_{weighted}$	46,188,768.57 (82.39%)		22,339,886.83 (28.48%)		68,528,655.40 (50.95%)		
At or Above Geometric Mean $_{unweighted}$	371.00 (22.18%)		1,153.00 (76.87%)		1,524.00 (48.03%)		
At or Above Geometric Mean $_{weighted}$	9,875,692.09 (17.61%)		56,097,685.94 (71.52%)		65,973,378.03 (49.05%)		
Methylmercury							
Below Geometric Mean $_{unweighted}$	1,444.00 (86.31%)		467.00 (31.13%)		1,911.00 (60.23%)	1,005.26 *<0.0001*	120.71 *0.0000*
Below Geometric Mean $_{weighted}$	48,846,413.75 (87.13%)		21,838,880.31 (27.84%)		70,685,294.07 (52.55%)		
At or Above Geometric Mean $_{unweighted}$	229.00 (13.69%)		1,033.00 (68.87%)		1,262.00 (39.77%)		
At or Above Geometric Mean $_{weighted}$	7,218,046.91 (12.87%)		56,598,692.46 (72.16%)		63,816,739.36 (47.45%)		
Sum of PCBs							
Below Geometric Mean $_{unweighted}$	1,302.00 (77.82%)		191.00 (12.73%)		1,493.00 (47.05%)	1,345.02 *<0.0001*	79.07 *0.0000*
Below Geometric Mean $_{weighted}$	37,983,127.71 (67.75%)		7,027,018.85 (8.96%)		45,010,146.57 (33.46%)		
At or Above Geometric Mean $_{unweighted}$	371.00 (22.18%)		1,309.00 (87.27%)		1,680.00 (52.95%)		
At or Above Geometric Mean $_{weighted}$	18,081,332.94 (32.25%)		71,410,553.92 (91.04%)		89,491,886.86 (66.54%)		

0 or 1 = all blood levels of lead, methylmercury and PCBs are below geometric mean OR
one blood level is at or above geometric mean and two blood levels are below geometric mean

2 or 3 = two blood levels are at or above geometric mean and one blood level is below geometric mean OR
all blood levels of lead, methylmercury and PCBs are at or above geometric mean

Table 37

Exposure as Outcome in Two Categories: Number of Pregnant Childbearing-Aged Females with Xenobiotic Blood Levels Below, At or Above the Geometric Mean (unweighted and weighted data 1999-2004)

Total Number of Chemicals At or Above Geometric Mean Sample Frequency $_{unweighted}$ Col. Pct. Population Estimated Frequency $_{weighted}$ Col. Pct. * = cell size < 30	0 and 1		2 and 3		Total	χ^2 *p value unweighted*	χ^2 *p value weighted*
Lead							
Below Geometric Mean $_{unweighted}$	204.00		56.00		260.00		
	(80.00%)		(41.18%)		(66.49%)		
Below Geometric Mean $_{weighted}$	2,329,096.35		1,292,921.09		3,622,017.44		
	(%)		(%)		(74.80%)		
At or Above Geometric Mean $_{unweighted}$	51.00		80.00		131.00	60.01	4.86
	(20.00%)		(58.82%)		(33.51%)	*<0.0001*	*0.033*
At or Above Geometric Mean $_{weighted}$	477,587.57		742,584.07		1,220,171.64		
	(9%)		(%)		(25.20%)		
Methylmercury							
Below Geometric Mean $_{unweighted}$	222.00		40.00		262.00		
	(87.06%)		(29.41%)		(67.00%)		
Below Geometric Mean $_{weighted}$	256,505.22		309,519.74		2,877,024.96		
	(51.75%)		(15.21%)		(59.42%)	133.33	24.07
At or Above Geometric Mean $_{unweighted}$	33.00		96.00		129.00	*<0.0001*	*0.0000*
	(12.94%)		(70.59%)		(33.00%)		
At or Above Geometric Mean $_{weighted}$	239,178.70		1,725,985.42		1,965,164.12		
	(48.25%)		(84.79%)		(40.58%)		
Sum of PCBs							
Below Geometric Mean $_{unweighted}$	221.00		*		235.00		
	(86.67%)		(0.00%)		(60.10%)		
Below Geometric Mean $_{weighted}$	2,292,279.40		135,932.33		2,428,211.73		
	(81.67%)		(6.68%)		(50.15%)	215.74	30.62
At or Above Geometric Mean $_{unweighted}$	34.00		122.00		156.00	*<0.0001*	*0.0000*
	(13.33%)		(89.71%)		(39.90%)		
At or Above Geometric Mean $_{weighted}$	514,404.53		1,899,572.84		2,413,977.37		
	(18.33%)		(93.32%)		(49.85%)		

0 or 1 = all blood levels of lead, methylmercury and PCBs are below geometric mean OR one blood level is at or above geometric mean and two blood levels are below geometric mean

2 or 3 = two blood levels are at or above geometric mean and one blood level is below geometric mean OR all blood levels of lead, methylmercury and PCBs are at or above geometric mean

Table 38
Estimated Prevalence Rates of Xenobiotic Blood Levels
Among Childbearing-Aged Female Participants (unweighted 1999 - 2004)

Individual Chemicals: Xenobiotic Blood Levels Below, At or Above Geometric Mean	Prevalence Rates Below Geometric Mean	Prevalence Rates At or Above Geometric Mean
Lead	51.97 per 100	48.03 per 100
Methylmercury	60.23 per 100	39.77 per 100
PCBs	47.05 per 100	52.95 per 100
Combinations of Chemicals: Both Concurrently At or Above Geometric Mean		Prevalence Rates
Lead and Methylmercury		54.36 per 100
Methylmercury and PCBs		50.12 per 100
PCBs and Lead		57.26 per 100
Exposure as Four Categories: Number of Chemicals Concurrently At or Above Geometric Mean		Prevalence Rates
0		22.12 per 100
1		30.60 per 100
2		31.67 per 100
3		15.60 per 100
Exposure as Two Categories: Number of Chemicals Concurrently At or Above Geometric Mean		Prevalence Rates
0 or 1		52.73 per 100
2 or 3		47.27 per 100

n = 3,173

Table 39
Estimated Prevalence Rates of Xenobiotic Blood Levels
Among Childbearing-Aged Females in U.S. (weighted 1999 - 2004)

Individual Chemicals: Xenobiotic Blood Levels Below, At or Above Geometric Mean	Prevalence Rates Below Geometric Mean	Prevalence Rates At or Above Geometric Mean
Lead	50.95 per 100	49.05 per 100
Methylmercury	52.55 per 100	47.45 per 100
PCBs	33.46 per 100	66.54 per 100
Combinations of Chemicals: Both Concurrently At or Above Geometric Mean		Prevalence Rates
Lead and Methylmercury		53.68 per 100
Methylmercury and PCBs		55.39 per 100
PCBs and Lead		74.38 per 100
Exposure as Four Categories: Number of Chemicals Concurrently At or Above Geometric Mean		Prevalence Rates
0		15.53 per 100
1		26.15 per 100
2		38.07 per 100
3		20.25 per 100
Exposure as Two Categories: Number of Chemicals Concurrently At or Above Geometric Mean		Prevalence Rates
0 or 1		41.68 per 100
2 or 3		58.32 per 100

n = 134,502,033.43

Table 40
Estimated Prevalence Rates of Xenobiotic Blood Levels
Among Pregnant Childbearing-Aged Participants (unweighted 1999 - 2004)

Individual Chemicals: Xenobiotic Blood Levels Below, At or Above Geometric Mean	Prevalence Rates Below Geometric Mean	Prevalence Rates At or Above Geometric Mean
Lead	66.49 per 100	33.51 per 100
Methylmercury	67.01 per 100	32.99 per 100
PCBs	60.11 per 100	39.89 per 100
Combinations of Chemicals: Both Concurrently At or Above Geometric Mean		Prevalence Rates
Lead and Methylmercury		31.01 per 100
Methylmercury and PCBs		52.56 per 100
PCBs and Lead		50.38 per 100
Exposure as Four Categories: Number of Chemicals Concurrently At or Above Geometric Mean		Prevalence Rates
0		19.52 per 100
1		12.15 per 100
2		10.95 per 100
3		*
Exposure as Two Categories: Number of Chemicals Concurrently At or Above Geometric Mean		Prevalence Rates
0 or 1		15.24 per 100
2 or 3		5.01 per 100

n = 391

Table 41
Estimated Prevalence Rates of Xenobiotic Blood Levels
Among Pregnant Childbearing-Aged Females in U.S. (weighted 1999 - 2004)

Individual Chemicals: Xenobiotic Blood Levels Below, At or Above Geometric Mean	Prevalence Rates Below Geometric Mean	Prevalence Rates At or Above Geometric Mean
Lead	74.81 per 100	25.19 per 100
Methylmercury	59.42 per 100	32.99 per 100
PCBs	50.15 per 100	49.85 per 100
Combinations of Chemicals: Both Concurrently At or Above Geometric Mean		Prevalence Rates
Lead and Methylmercury		22.04 per 100
Methylmercury and PCBs		65.87 per 100
PCBs and Lead		49.72 per 100
Exposure as Four Categories: Number of Chemicals Concurrently At or Above Geometric Mean		Prevalence Rates
0		7.54 per 100
1		3.50 per 100
2		3.39 per 100
3		1.09 per 100
Exposure as Two Categories: Number of Chemicals Concurrently At or Above Geometric Mean		Prevalence Rates
0 or 1		9.07 per 100
2 or 3		2.60 per 100

n = 4,842,189.09

Table 42
Bivariate Analyses of Independent Variables on Exposure as Outcome with Two Categories Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	0 and 1		2 and 3		χ^2 *p value unweighted*	χ^2 *p value weighted*
Susceptibility-Related Attributes						
Age (age4cat)						
16-19^{R}	781.00 (46.68%) 14,660,569.05 (26.15%)		304.00 (20.27%) 3,849,899.68 (4.91%)			
20-29	520.00 (31.08%) 23,750,605.62 (42.36%)		364.00 (24.27%) 21,596,909.29 (27.53%)		446.40 *<0.0001*	18.38 *0.0000*
30-39	275.00 (16.44%) 12,303,495.51 (21.95%)		427.00 (28.47%) 24,054,340.99 (30.67%)			
40-49	97.00 (5.80) 5,349,790.48 (9.54%)		405.00 (27.00%) 28,936,422.82 (36.89%)			
Health Status						
Perceived Health Status (huq2cat)						
excellent, very good, good^{R}	1,523.00 (91.03%) 51,900,967.08 (92.57%)		1,317.00 (87.86%) 72,104,278.01 (91.96%)		8.51 *0.0035*	0.15 *0.696*
fair, poor	150.00 (8.97%) 4,163,493.57 (7.43%)		182.00 (12.14%) 6,302,386.02 (8.04%)			
Charleson Co-Morbidity Scale (CCMS3cat)						
none^{R}	1,480.00 (88.46%) 48,153,165.73 (85.89%)		1,334.00 (88.93%) 70,103,855.70 (89.38%)			
one co-morbidity	173.00 (10.34%) 6,875,028.46 (12.26%)		130.00 (8.67%) 6,271,704.85 (8.00%)		8.84 *0.012*	1.08 *0.347*
more than one co-morbidity	* (0.00%) 1,036,266.46 (1.85%)		36.00 (2.40%) 2,062,012.23 (2.63%)			
Iron Deficiency (FeD2cat)						
within normal limits^{R}	1,421.00 (84.94%) 51,036,315.36 (91.03%)		1,303.00 (86.87%) 71,800,443.27 (91.54%)		2.42 *0.119*	0.07 *0.791*
iron deficient	252.00 (15.06%) 5,028,145.30 (8.97%)		197.00 (13.13%) 6,637,129.51 (8.46%)			
Treatment for Iron Deficiency past 3 mo (FeTx2cat)						
yes	93.00 (5.56%) 2,101,128.65 (3.75%)		78.00 (5.20%) 3,045,167.32 (3.88%)		0.19 *0.658*	0.005 *0.942*
no^{R}	1,580.00 (94.44%) 53,963,332.01 (96.25%)		1,421.00 (94.80%) 75,378,826.38 (96.12%)			

Table 42
Bivariate Analyses of Independent Variables on Exposure as Outcome with Two Categories Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	0 and 1		2 and 3		χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
Iron Deficiency and Treatment (FeDTx)						
	1,357.00		1,251.00			
	(81.11%)		(83.46%)			
	49,651,905.68		69,790,793.00			
normal/no treatment^{R}	(88.56%)		(88.99%)			
	64.00		51.00			
	(3.83%)		(3.40%)			
	1,384,409.68		1,996,071.19		3.46	0.54
normal w/treatment	(2.47%)		(2.55%)		*0.326*	*0.983*
	*		*			
	(0.00%)		(0.00%)			
	716,718.97		1,049,096.13			
deficient w/treatment	(1.28%)		(1.34%)			
	223.00		170.00			
	(13.33%)		(11.34%)			
	4,311,426.33		5,588,033.38			
deficient/no treatment	(7.69%)		(7.13%)			
Health Insurance (hi2cat)						
	1,053.00		989.00			
	(62.94%)		(65.93%)			
	41,460,120.89		58,672,657.58			
private^{R}	(73.95%)		(74.80%)			
	267.00		172.00			
	(15.96%)		(11.47%)			
	4,425,605.00		5,365,815.08		14.85	0.19
public	(7.89%)		(6.84%)		*0.002*	*0.901*
	311.00		308.00			
	(18.59%)		(20.53%)			
	8,880,950.82		12,881,853.55			
none	(15.84%)		(16.42%)			
	42.00		31.00			
	(2.51%)		(2.07%)			
	1,297,783.95		1,517,246.57			
missing	(2.31%)		(1.93%)			
Regular Source of Healthcare (hp2cat)						
	1,407.00		1,266.00			
	(84.10%)		(84.40%)			
	47,714,928.87		67,743,353.45			
yes^{R}	(85.11%)		(86.37%)		0.053	0.07
	266.00		234.00		*0.817*	*0.797*
	(15.90%)		(15.60%)			
	8,349,531.79		10,694,219.32			
no	(14.89%)		(13.63%)			
Source of Healthcare (hcsre)						
	908.00		899.00			
	(54.27%)		(59.93%)			
	33,642,652.17		51,519,187.82			
healthcare provider^{R}	(60.01%)		(65.58%)			
	399.00		277.00			
	(23.85%)		(18.47%)			
	11,321,776.58		12,446,320.30		15.44	0.82
clinic	(20.19%)		(15.87%)		*0.0015*	*0.489*
	339.00		303.00			
	(20.26%)		(20.20%)			
	9,623,922.51		13,338,734.24			
ER or none	(17.17%)		(17.01%)			
	27.00		21.00			
	(1.61%)		(1.40%)			
	1,476,109.39		1,133,330.41			
missing	(2.63%)		(1.44%)			

Table 42
Bivariate Analyses of Independent Variables on Exposure as Outcome with Two Categories Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	0 and 1		2 and 3		χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
Nutritional Status						
Food Security (food2cat)						
	1,333.00		1,239.00			
	(79.68%)		(82.60%)			
	46,653,491.95		67,390,420.71			
food secure^{R}	(83.21%)		(85.92%)			
	271.00		188.00		9.15	4.49
	(16.20%)		(12.53%)		*0.010*	*0.017*
	7,205,478.55		7,029,043.50			
food insecure	(12.85%)		(8.96%)			
	69.00		73.00			
	(4.12%)		(4.87%)			
	2,205,490.16		4,018,108.56			
missing	(3.93%)		(5.12%)			
Body Mass Index (bmi30cat)						
<30.0^{R}	1,217.00		1,140.00			
underweight	(72.74%)		(76.00%)			
normal	41,844,407.61		60,999,489.31			
overweight	(74.64%)		(77.77%)			
	430.00		347.00		6.30	0.69
	(25.70%)		(23.13%)		*0.430*	*0.507*
30.0+	13,438,670.22		16,777,787.58			
obese	(23.97%)		(21.39%)			
	26.00		13.00			
	(1.55%)		(0.87%)			
	781,382.83		660,295.88			
missing	(1.39%)		(0.84%)			
Fat Intake/AMDR (fat3cat)						
	1,020.00		878.00			
	(60.97%)		(58.53%)			
	33,215,112.27		47,929,229.77			
recommended or less^{R}	(59.24%)		(61.10%)		1.95	0.16
	653.00		622.00		*0.1625*	*0.690*
	(39.03%)		(41.47%)			
	22,849,348.38		30,508,343.01			
more than recommended	(40.76%)		(38.90%)			
Protein Intake/AMDR (prot3cat)						
	1,440.00		1,272.00			
	(86.07%)		(84.80%)			
	49,359,245.64		69,404,519.64			
recommended or more^{R}	(88.04%)		(88.48%)		1.03	0.03
	233.00		228.00		*0.309*	*0.857*
	(13.93%)		(15.20%)			
	6,705,215.02		9,033,053.14			
less than recommended	(11.96%)		(11.52%)			
Iron Intake/RDA (iron2cat)						
	507.00		422.00			
	(30.30%)		(28.13%)			
	14,985,849.52		18,523,830.10			
recommended or more^{R}	(26.73%)		(23.62%)		1.80	0.56
	1,166.00		1,078.00		*0.1796*	*0.460*
	(69.70%)		(71.87%)			
	41,078,611.14		59,913,742.68			
less than recommended	(73.27%)		(76.38%)			
Calcium Intake/RDA (calc2cat)						
	449.00		396.00			
	(26.84%)		(26.40%)			
	15,850,605.09		26,711,938.83			
recommended or more^{R}	(28.27%)		(34.06%)		0.08	0.94
	1,224.00		1,104.00		*0.780*	*0.337*
	(73.16%)		(73.60%)			
	40,213,855.57		51,725,633.94			
less than recommended	(71.73%)		(65.94%)			

Table 42
Bivariate Analyses of Independent Variables on Exposure as Outcome with Two Categories Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	0 and 1	2 and 3	χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
Selenium Intake/RDA (sele2cat)				
recommended or more^{R}	1,326.00 (79.26%) 44,641,673.61 (79.63%)	1,233.00 (82.20%) 68,036,809.25 (86.74%)	4.38 *0.036*	4.61 *0.040*
less than recommended	347.00 (20.74%) 11,422,787.05 (20.37%)	267.00 (17.80%) 10,400,763.53 (13.26%)		
Reproductive Status				
Current Pregnancy (pregnant)				
pregnant	255.00 (15.24%) 2,806,683.92 (5.01%)	136.00 (9.07%) 2,035,505.17 (2.60%)		
not pregnant^{R}	1,351.00 (80.5%) 51,426,908.09 (91.73%)	1,290.00 (86.00%) 74,949,610.84 (95.55%)	28.63 *<0.0001*	4.09 *0.023*
missing	67.00 (4.00%) 1,830,868.64 (3.27%)	74.00 (4.93%) 1,452,456.76 (1.85%)		
Trimester of Pregnancy (tripcorr)				
not pregnant^{R}	1,418.00 (84.76%) 53,257,776.74 (94.99%)	1,364.00 (90.93%) 76,402,067.61 (97.40%)		
1st trimester	77.00 4.60%) 1,114,818.61 (1.99%)	72.00 (4.80%) 876,747.50 (1.12%)	46.19 *<0.0001*	2.35 *0.085*
2nd trimester	100.00 (5.98%) 973,564.59 (1.74%)	32.00 (2.13%) 549,930.94 (0.70%)		
3rd trimester	78.00 (4.66%) 718,300.72 (1.28%)	32.00 (2.13%) 608,826.72 (0.78%)		
Ever Pregnant (tprg2cat)				
never pregnant^{R}	936.00 (55.95%) 30,643,248.04 (54.66%)	599.00 (39.93%) 28,921,848.94 (36.87%)	81.21 *<0.0001*	13.36 *0.0007*
one or more pregnancies	737.00 (44.05%) 25,421,212.62 (45.34%)	901.00 (60.07%) 49,515,723.83 (63.13%)		
Live Births (live)				
no live births^{R}	1,095.00 (65.45%) 34,042,014.38 (60.72%)	725.00 (48.33%) 33,378,223.83 (42.55%)	94.75 *<0.0001*	15.34 *0.0003*
one or more live births	578.00 (34.55%) 22,022,446.27 (39.28%)	775.00 (51.67%) 45,059,348.94 (57.45%)		

Table 42
Bivariate Analyses of Independent Variables on Exposure as Outcome with Two Categories Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	0 and 1		2 and 3		χ^2 *p value unweighted*	χ^2 *p value weighted*
Ever Breastfed (brstfda)						
never breastfed^{R}	1,276.00 (76.27%) 40,009,667.89 (71.36%)		1,047.00 (69.80%) 51,944,654.41 (66.22%)		16.88 *<0.0001*	2.02 *0.162*
breastfed more than one month and/or currently	397.00 (23.73%) 16,054,792.77 (28.54%)		453.00 (30.20%) 26,492,918.36 (33.78%)			
Exposure-Related Attributes						
Acculturation						
Birthplace (born2cat)						
U.S.^{R}	1,421.00 (84.94%) 49,686,661.17 (88.62%)		1,252.00 (83.47%) 70,617,035.63 (90.03%)		1.28 *0.256*	0.37 *0.545*
outside U.S.	252.00 (15.06%) 6,377,799.49 (11.38%)		248.00 (16.53%) 7,820,537.14 (9.97%)			
Years in U.S. (yrus5)						
born in U.S.^{R}	1,421.00 (85.04%) 49,686,661.17 (88.67%)		1,252.00 (83.69%) 70,617,035.63 (90.19%)			
five or more years	170.00 (10.17%) 4,699,016.12 (8.39%)		182.00 (12.17%) 6,374,503.09 (8.14%)		3.72 *0.156*	1.26 *0.292*
less than five years	80.00 (4.79%) 1,652,073.94 (2.95%)		62.00 (4.14%) 1,303,892.97 (1.67%)			
Language Spoken at Home (lang2cat)						
English^{R}	1,510.00 (90.26%) 52,407,413.27 (93.48%)		1,334.00 (89.05%) 74,353,781.09 (95.07%)		1.24 *0.265*	1.57 *0.217*
Other	163.00 (9.74%) 3,657,047.38 (6.52%)		164.00 (10.95%) 3,856,724.33 (4.93%)			
U.S. Citizenship (usczn2cat)						
U.S. citizen^{R}	1,490.00 (89.06%) 52,431,440.49 (93.52%)		1,324.00 (88.33%) 74,393,831.42 (94.87%)		0.43 *0.513*	0.99 *0.324*
non-U.S. citizen	183.00 (10.94%) 3,633,020.17 (6.48%)		175.00 (11.67%) 4,021,872.67 (5.13%)			
Diet						
Seafood Eaten in Past 30 Days (smpw2cat)						
none^{R}	483.00 (28.87%) 14,572,597.13 (25.99%)		203.00 (13.53%) 8,298,243.66 (10.58%)		109.78 *<0.0001*	22.36 *0.0000*
any	1,190.00 (71.13%) 41,491,863.53 (74.01%)		1,297.00 (86.47%) 70,139,329.12 (89.42%)			

Table 42
Bivariate Analyses of Independent Variables on Exposure as Outcome with Two Categories Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	0 and 1		2 and 3		χ^2 *p value unweighted*	χ^2 *p value weighted*
Fish Eaten in Past 30 Days (fish2cat)						
none[R]	715.00 (42.74%) 22,681,779.88 (40.46%)		325.00 (21.67%) 14,127,959.80 (18.01%)		159.37 *<0.0001*	40.16 *0.0000*
any	958.00 (57.26%) 33,382,680.78 (59.54%)		1,175.00 (78.33%) 6,4309,612.98 (81.99%)			
Shellfish Eaten in Past 30 Days (shell2cat)						
none[R]	941.00 (56.25%) 30,638,660.38 (54.65%)		616.00 (41.07%) 32,379,978.80 (41.28%)		72.92 *<0.0001*	7.60 *0.0085*
any	732.00 (43.75%) 25,425,800.28 (45.35%)		884.00 (58.93%) 46,057,593.97 (58.72%)			
Tap Water Consumed Prior 24h (tap2kct)						
none[R]	654.00 (39.09%) 19,341,590.85 (34.50%)		475.00 (31.67%) 21,163,237.39 (26.98%)			
< 2,000 ml	775.00 (46.32%) 27,284,851.16 (48.67%)		763.00 (50.87%) 43,760,634.26 (55.79%)		33.78 *<0.0001*	2.03 *0.122*
2,000+ ml	163.00 (9.74%) 6,637,991.60 (11.84%)		132.00 (8.80%) 8,891,560.90 (11.34%)			
missing=1	81.00 (4.84%) 2,800,027.04 (4.99%)		130.00 (8.67%) 4,622,140.22 (5.89%)			
Alcohol Consumption						
Alcohol Consumption (retohuse)						
never, seldom drinker[R] *including 16-19 y/o*	1,076.00 (64.32%) 26,791,446.13 (47.79%)		667.00 (44.47%) 25,429,069.23 (32.42%)			
drinker	349.00 (20.86%) 16,087,057.48 (28.69%)		381.00 (25.40%) 24,583,022.09 (31.34%)		148.84 *<0.0001*	6.50 *0.0010*
heavy drinker	202.00 (12.07%) 11,799,383.44 (21.05%)		353.00 (23.53%) 23,965,996.00 (30.55%)			
missing	46.00 (2.75%) 1,386,573.60 (2.47%)		99.00 (6.60%) 4,459,485.45 (5.69%)			
Tobacco Use						
Serum Cotinine (cot3cat)						
< 1.0 ng/ml[R]	1,310.00 (78.77%) 42,870,593.92 (76.89%)		1,058.00 (70.77%) 56,000,879.65 (71.69%)			
1.0 - 10.0 ng/ml	103.00 (6.19%) 2,911,068.62 (5.22%)		87.00 (5.82%) 2,339,233.00 (2.99%)		35.99 <0.0001	4.30 *0.0197*
> 10.0 ng/ml	250.00 (15.03%) 9,977,616.00 (17.89%)		350.00 (23.41%) 19,772,725.24 (25.31%)			

Table 42

Bivariate Analyses of Independent Variables on Exposure as Outcome with Two Categories Among Childbearing-Aged Females

(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	0 and 1		2 and 3		χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
ETS (ETS)						
no ETS^{R}	1,273.00 (76.09%) 42,613,280.22 (76.01%)		1,144.00 (76.27%) 59,184,091.36 (75.45%)			
ETS at home or work	347.00 (20.74%) 11,530,060.37 (20.57%)		303.00 (20.20%) 15,176,809.23 (19.35%)		0.432 *0.805*	0.41 *0.666*
ETS at home and work	53.00 (3.17%) 1,921,120.07 (3.43%)		53.00 (3.53%) 4,076,672.18 (5.20%)			
Residence						
Tap Water Source (h2os2cat)						
public^{R}	1,470.00 (87.87%) 48,669,218.11 (86.81%)		1,356.00 (90.40%) 68,066,690.05 (86.78%)			
private	160.00 (9.56%) 6,135,157.79 (10.94%)		106.00 (7.07%) 8,356,377.23 (10.65%)		6.46 *0.039*	0.03 *0.968*
missing	43.00 (2.57%) 1,260,084.76 (2.25%)		38.00 (2.53%) 2,014,505.49 (2.57%)			
Residential Tap Water Treatment (h2ox2cat)						
yes	470.00 (28.09%) 18,237,088.22 (32.58%)		393.00 (26.20%) 27,071,146.45 (34.51%)			
no^{R}	1,167.00 (69.75%) 36,752,210.02 (65.55%)		1,072.00 (71.47%) 49,793,127.34 (63.48%)		1.49 *0.475*	0.08 *0.925*
missing	36.00 (2.15%) 1,075,162.42 (1.92%)		35.00 (2.33%) 1,573,298.98 (2.01%)			
Type of Residence (res3cat)						
attached or detached house^{R}	1,066.00 (63.72%) 35,113,061.69 (62.63%)		1,006.00 (67.07%) 54,192,908.87 (69.09%)			
mobile home or trailer	107.00 (6.40%) 3,865,488.99 (6.89%)		95.00 (6.33%) 4,536,288.81 (5.78%)		4.38 *0.112*	1.29 *0.286*
all other types *including missing/unknown*	500.00 (29.89%) 17,085,909.98 (30.48%)		399.00 (26.60%) 19,708,375.09 (25.13%)			

Table 42
Bivariate Analyses of Independent Variables on Exposure as Outcome with Two Categories Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	0 and 1	2 and 3	χ^2 *p value unweighted*	χ^2 *p value weighted*
Age of Residence (resb60cat)				
1960 or newer[R]	841.00 (50.27%) 32,355,341.90 (57.71%)	754.00 (50.27%) 45,689,182.12 (58.25%)		
older than 1960	404.00 (24.15%) 12,895,677.19 (23.00%)	362.00 (24.16%) 19,196,522.91 (24.47%)	0.00 *0.999*	0.20 *0.815*
missing/unknown	428.00 (25.58%) 10,813,441.57 (19.29%)	384.00 (25.60%) 13,551,867.74 (17.28%)		
Age of Residence (resb78cat)				
1978 or newer[R]	547.00 (32.70%) 21,828,679.09 (38.93%)	540.00 (36.00%) 33,559,369.76 (42.78%)		
older than 1978	698.00 (41.72%) 23,422,340.00 (41.78%)	576.00 (38.40%) 31,326,335.27 (39.94%)	4.69 *0.096*	0.36 *0.699*
missing/unknown	428.00 (25.58%) 10,813,441.57 (19.29%)	384.00 (25.60%) 13,551,867.74 (17.28%)		
Resident Status (resd3cat)				
own[R]	887.00 (53.02%) 31,914,972.43 (56.93%)	840.00 (56.00%) 45,335,334.69 (57.80%)		
rent	676.00 (40.41%) 20,737,390.37 (36.99%)	602.00 (40.13%) 30,426,505.20 (38.79%)	12.26 *0.002*	0.77 *0.466*
other *including missing*	110.00 (6.58%) 3,412,097.85 (6.09%)	58.00 (3.87%) 2,675,732.88 (3.41%)		
Years at Current Residence (re5yrcat)				
more than five years[R]	555.00 (33.17%) 18,106,390.76 (32.30%)	558.00 (37.20%) 27,787,927.92 (35.43%)		
five years or less	1,095.00 (65.45%) 37,302,721.50 (66.54%)	912.00 (60.80%) 49,152,891.44 (62.66%)	8.21 *0.016*	0.46 *0.634*
missing	23.00 (1.37%) 655,348.40 (1.17%)	30.00 (2.00%) 1,496,753.41 (1.91%)		
Household Size (hsize)				
four persons or less[R]	1,091.00 (65.21%) 41,630,345.58 (74.25%)	1,091.00 (72.73%) 64,823,682.81 (82.64%)		
more than four persons	582.00 (34.79%) 14,434,115.08 (25.75%)	409.00 (27.27%) 13,613,889.97 (17.36%)	20.83 *<0.0001*	5.43 *0.024*

Table 42
Bivariate Analyses of Independent Variables on Exposure as Outcome with Two Categories Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	0 and 1		2 and 3		χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
Rooms in Residence (rm3cat)						
7+ rooms^{R}	610.00 (36.46%) 22,384,013.42 (39.93%)		538.00 (35.87%) 30,232,499.39 (38.54%)			
4-6 rooms	892.00 (53.32%) 28,129,923.41 (50.17%)		799.00 (53.27%) 40,970,209.18 (52.23%)		0.89 *0.827*	0.05 *0.982*
1-3 rooms	132.00 (7.89%) 4,412,246.48 (7.87%)		131.00 (8.73%) 5,762,926.63 (7.35%)			
missing	39.00 (2.33%) 1,138,277.35 (2.03%)		32.00 (2.13%) 1,471,937.57 (1.88%)			
Occupation						
Current Occupation (cocc2cat)						
not working^{R}	757.00 (45.25%) 18,579,398.21 (33.14%)		567.00 (37.80%) 23,593,559.36 (30.08%)			
management, professional & sales	598.00 (35.74%) 25,983,638.35 (46.35%)		645.00 (43.00%) 41,775,253.39 (53.26%)		21.16 *<0.0001*	1.01 *0.374*
services & goods	318.00 (19.01%) 11,501,424.09 (20.51%)		288.00 (19.20%) 13,068,760.03 (16.66%)			
Time in Current Employment (cjt)						
not working^{R}	757.00 (45.25%) 18,579,398.21 (33.14%)		567.00 (37.80%) 23,593,559.36 (30.08%)			
less than five years	781.00 (46.68%) 30,471,853.31 (54.36%)		653.00 (43.53%) 36,769,786.41 (46.88%)		80.16 *<0.0001*	3.86 *0.028*
five or more years	135.00 (8.07%) 7,013,209.13 (12.51%)		280.00 (18.67%) 18,074,227.00 (23.04%)			
Total Hours Worked Prior Week (hrwk)						
not employed^{R}	786.00 (47.01%) 19,977,686.48 (35.71%)		595.00 (39.69%) 25,830,351.54 (32.94%)			
less than 35 hours	418.00 (25.00%) 13,916,897.10 (24.88%)		318.00 (21.21%) 19,450,536.69 (24.80%)		43.91 *<0.0001*	0.15 *0.859*
35+ hours	468.00 (27.99%) 22,046,705.15 (39.41%)		586.00 (39.09%) 33,134,815.85 (42.26%)			

Table 42
Bivariate Analyses of Independent Variables on Exposure as Outcome with Two Categories Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	0 and 1		2 and 3		χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
Longest Held Occupation (locc2cat)						
not applicable^{R}	836.00 (49.97%) 28,223,195.93 (50.34%)		726.00 (48.40%) 35,894,160.58 (45.76%)			
management, professional & sales	436.00 (26.06%) 15,629,691.43 (27.88%)		467.00 (31.13%) 25,785,494.72 (32.87%)		11.89 *0.0026*	0.79 *0.460*
services & goods	401.00 (23.97%) 12,211,573.30 (21.78%)		307.00 (20.47%) 16,757,917.47 (21.36%)			
Time in Longest Employment (ljt)						
not applicable^{R}	836.00 (49.97%) 28,223,195.93 (50.34%)		726.00 (48.40%) 35,894,160.58 (45.76%)			
less than five years	629.00 (37.60%) 19,448,228.46 (34.69%)		368.00 (24.53%) 15,094,040.39 (19.24%)		130.88 *<0.0001*	5.74 0.0061
five or more years	208.00 (12.43%) 8,393,036.27 (14.97%)		406.00 (27.07%) 27,449,371.80 (35.00%)			
Socioeconomic Factors						
Education						
Highest Education (educ2)						
high school diploma, GED or higher^{R}	954.00 (57.02%) 41,908,990.51 (74.75%)		1,083.00 (72.25%) 64,998,170.83 (82.94%)			
less than high school diploma	719.00 (42.98%) 14,155,470.15 (25.25%)		416.00 (27.75%) 13,372,263.15 (17.06%)		79.75 *<0.0001*	5.20 *0.027*
Employment						
Employment Status (emp3cat)						
employed	917.00 (54.88%) 37,506,551.23 (66.91%)		936.00 (62.40%) 54,962,248.73 (70.07%)			
not employed^{R}	754.00 (45.12%) 18,546,689.91 (33.09%)		564.00 (37.60%) 23,475,324.04 (29.93%)		18.42 *<0.0001*	0.25 *0.619*
Reason for Unemployment (unem2cat)						
working^{R}	917.00 (54.81%) 37,506,551.23 (66.90%)		936.00 (62.40%) 54,962,248.73 (70.07%)			
voluntary unemployment	533.00 (31.86%) 12,975,338.65 (23.14%)		391.00 (26.07%) 15,289,683.02 (19.49%)			
involuntary unemployment	144.00 (8.61%) 3,625,315.15 (6.47%)		151.00 (10.07%) 6,637,798.86 (8.46%)		45.05 *<0.0001*	0.77 *0.517*
missing	79.00 (4.72%) 1,957,255.62 (3.49%)		22.00 (1.47%) 1,547,842.16 (1.97%)			

Table 42
Bivariate Analyses of Independent Variables on Exposure as Outcome with Two Categories Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	0 and 1		2 and 3		χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
Work History (wkcp)						
never employed^{R}	259.00 (15.48%) 4,501,108.85 (8.03%)		149.00 (9.93%) 3,737,701.95 (4.77%)			
currently employed	577.00 (34.49%) 23,722,087.08 (42.31%)		577.00 (38.47%) 32,156,458.63 (41.00%)		27.71 <0.0001	1.49 *0.229*
employed in the past but not currently	498.00 (29.77%) 14,078,289.37 (25.11%)		418.00 (27.87%) 19,855,857.41 (25.31%)			
employed now and in the past	339.00 (20.6%) 13,762,975.36 (24.55%)		356.00 (23.73%) 22,687,554.78 (28.92%)			
Income						
U.S. Poverty Threshold (pov2cat)						
more than 1.00^{R}	1,159.00 (69.28%) 42,663,631.82 (76.10%)		1,068.00 (71.20%) 61,289,991.37 (78.14%)			
1.00 or less	416.00 (24.87%) 9,918,920.81 (17.69%)		314.00 (20.93%) 12,668,276.66 (16.15%)		10.42 *0.005*	0.085 *0.919*
missing	98.00 (5.86%) 3,481,908.03 (6.21%)		118.00 (7.87%) 4,479,304.74 (5.71%)			
Marital Status						
Marital Status (marr3cat)						
married or living with partner	546.00 (32.64%) 22,312,508.65 (39.80%)		652.00 (43.47%) 39,488,139.60 (50.34%)			
widowed, divorced or separated	81.00 (4.84%) 3,129,387.79 (5.58%)		180.00 (12.00%) 11,224,564.59 (14.31%)		158.07 *<0.0001*	11.95 *0.0000*
never married^{R}	1,025.00 (61.27%) 29,803,777.82 (53.16%)		612.00 (40.80%) 23,689,173.67 (30.20%)			
missing	21.00 (1.26%) 818,786.41 (1.46%)		56.00 (3.73%) 4,035,694.90 (5.15%)			

Table 42
Bivariate Analyses of Independent Variables on Exposure as Outcome with Two Categories Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables with Exposure Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	0 and 1		2 and 3		χ^2 *p value* *unweighted*	χ^2 *p value* *weighted*
Race-Ethnicity						
Race-Ethnicity (race5cat)						
Non-Hispanic White^{R}	762.00 (45.55%) 39,164,389.13 (69.86%)		731.00 (48.73%) 58,723,155.03 (74.87%)			
Non-Hispanic Black	295.00 (17.63%) 4,574,953.56 (8.16%)		328.00 (21.87%) 8,172,224.81 (10.42%)			
Mexican American	440.00 (26.30%) 5,007,799.19 (8.93%)		305.00 (20.33%) 3,662,776.62 (4.67%)		23.29 *0.0001*	2.67 *0.044*
Other Hispanic	104.00 (6.22%) 3,953,960.50 (7.05%)		74.00 (4.93%) 3,572,031.72 (4.55%)			
Asian, Native American, Pacific Islander & Multi-Racial	72.00 (4.30%) 3,363,358.28 (6.00%)		62.00 (4.13%) 4,307,384.60 (5.49%)			
Race-Ethnicity/Hispanic Grouping (race4cat)						
Non-Hispanic White^{R}	762.00 (45.55%) 39,164,389.13 (69.86%)		731.00 (48.73%) 58,723,155.03 (74.87%)			
Non-Hispanic Black	295.00 (17.63%) 4,574,953.56 (8.16%)		328.00 (21.87%) 8,172,224.81 (10.42%)		23.27 *<0.0001*	3.28 *0.029*
Hispanic	544.00 (32.52%) 8,961,759.69 (15.98%)		379.00 (25.27%) 7,234,808.34 (9.22%)			
Asian, Native American, Pacific Islander & Multi-Racial	72.00 (4.30%) 3,363,358.28 (6.00%)		62.00 (4.13%) 4,307,384.60 (5.49%)			

Table 43

Summary of Chi-Square (χ^2) and p Values of Weighted Independent Variables on Exposure as Outcome with Two Categories (1999-2004)

Variables *p < 0.20*	*p* value	χ^2 *weighted*	Variables *p > 0.20*	*p* value	χ^2 *weighted*
Fish in Past 30 Days (fish2cat)	*0.000*	40.16	Language Spoken at Home (lang2cat)	*0.217*	1.57
Seafood in Past 30 Days [1] (smpw2cat)	*0.000*	22.36	Work History (wkcp)	*0.229*	1.49
Age (age4cat)	*0.000*	18.38	Type of Residence (res3cat)	*0.286*	1.29
Marital Status (marr3cat)	*0.000*	11.95	Years in U.S. (yrus5)	*0.292*	1.26
Live Births (live)	*0.000*	15.34	U.S. Citizenship (usczn2cat)	*0.324*	0.99
Ever Pregnant[1] (tprg2cat)	*0.001*	13.36	Calcium Intake/RDA (calc2cat)	*0.337*	0.94
Alcohol Consumption (retohuse)	*0.001*	6.50	Charleson Co-Morbidity Index (CCMS3cat)	*0.347*	1.08
Time in Longest Employment (ljt)	*0.006*	5.74	Current Occupation (cocc2cat)	*0.374*	1.01
Shellfish in Past 30 Days (shell2cat)	*0.009*	7.60	Longest Held Occupation (locc2cat)	*0.460*	0.79
Food Security (food2cat)	*0.017*	4.49	Iron Intake/RDA (iron2cat)	*0.460*	0.56
Serum Cotinine (cot3cat)	*0.019*	4.30	Resident Status (resd3cat)	*0.466*	0.77
Current Pregnancy (pregnant)	*0.023*	4.09	Source of Healthcare (hcsre)	*0.489*	0.82
Household Size (hsize)	*0.024*	5.43	Body Mass Index (bmi30cat)	*0.507*	0.69
Highest Education (educ2)	*0.027*	5.20	Reason for Unemployment (unem2cat)	*0.517*	0.77
Time in Current Employment (cjt)	*0.028*	3.86	Birthplace (born2cat)	*0.545*	0.37
Race-Ethnicity/Hispanic Grouping (race4cat)	*0.029*	3.28	Employment Status (emp3cat)	*0.619*	0.25
Selenium Intake/RDA (sele2cat)	*0.040*	4.61	Years at Current Residence (re5yrcat)	*0.634*	0.46
Race-Ethnicity[1] (race5cat)	*0.044*	2.67	Environmental Tobacco Smoke (ETS)	*0.666*	0.41
Trimester of Pregnancy[1] (tripcorr)	*0.085*	2.35	Perceived Health Status (huq2cat)	*0.696*	0.15
Tap Water Consumed 24h (tap2kct)	*0.122*	2.03	Age of Residence (resb78cat)	*0.699*	0.36
Ever Breastfed (brstfda)	*0.162*	2.02	Fat Intake/AMDR (fat3cat)	*0.732*	0.12
			Iron Deficiency (FeD2cat)	*0.791*	0.07
			Regular Source of Healthcare (hp2cat)	*0.797*	0.07
			Age of Residence (resb60cat)	*0.815*	0.20
			Protein Intake/AMDR (prot3cat)	*0.857*	0.03
			Total Hours Worked Prior Week (hrwk)	*0.859*	0.15
			Health Insurance (hi2cat)	*0.901*	0.19
			U.S. Poverty Threshold (pov2cat)	*0.919*	0.08
			Residential Tap Water Treatment (h2ox2cat)	*0.925*	0.08
			Treatment for Iron Deficiency past 3 mo (FeTx2cat)	*0.942*	0.00
			Tap Water Source (h2os2cat)	*0.968*	0.03
			Rooms in Residence (rm3cat)	*0.982*	0.05
			Iron Deficiency and Treatment (FeDTx)	*0.983*	0.54

[1]variable dropped due to low cell size or too similar to other variables

Table 44
Stepwise Logistic Regression Analyses of Exposure as Outcome with Two Categories
(1999 - 2004)

Variable Name *p < 0.20*	df	-2LL Wald F	Difference	df	*p* value
Initial Regression	32	1,018.12			
1 Time in Current Employment (cjt)	30	1,014.32	3.80	2	*>0.10* *drop*
2 Tap Water Consumed 24h (tap2kct)	27	1,009.88	1.63	3	*>0.20* *drop*
3 Live Births (live)	26	1,008.06	1.82	1	*>0.10* *drop*
4 Race-Ethnicity/Hispanic Grouping (race4cat)	23	992.69	15.37	3	*<0.01* *keep*
5 Current Pregnancy (pregnant)	24	1,002.16	5.90	2	*>0.05* *drop*
6 Serum Cotinine (cot3cat)	22	993.50	8.66	2	*<0.02* *keep*
7 Household Size (hsize)	23	993.78	8.38	1	*<0.01* *keep*
8 Time in Longest Employment (ljt)	22	974.08	28.08	2	*<0.001* *keep*
9 Highest Education (educ2)	23	973.50	28.66	1	*<0.001* *keep*
10 Marital Status (marr3cat)	21	960.42	41.74	3	*<0.001* *keep*
11 Age (age4cat)	21	686.92	315.24	3	*<0.001* *keep*
12 Food Security (food2cat)	22	955.84	46.32	2	*<0.001* *keep*
13 Selenium Intake/RDA (sele2cat)	23	990.31	11.85	1	*<0.001* *keep*
14 Ever Breastfed (brstfda)	23	977.17	24.99	1	*<0.001* *keep*
15 Fish in Past 30 Days (fish2cat)	23	877.76	124.40	1	*<0.001* *keep*
16 Shellfish in Past 30 Days (shell2cat)	23	980.03	22.13	1	*<0.001* *keep*
17 Alcohol Consumption (retohuse)	21	970.95	31.21	3	*<0.001* *keep*

Table 45
Best-Fit Logistic Regression Exposure Model *with no interactions*
(1999 - 2004)

Variable Name *in ascending order by p value*	df	-2LL Wald F	R^2		*p* value
Best Fit Regression	24	1,002.16	*0.2719*		
Fish in Past 30 Days (fish2cat)	1	26.26			*0.0000*
Age (age4cat)	3	11.92			*0.0000*
Food Security (food2cat)	2	5.94			*0.0052*
Ever Breastfed (brstfda)	1	5.32			*0.0258*
Highest Education (educ2)	1	3.81			*0.0572*
Shellfish in Past 30 Days (shell2cat)	1	3.73			*0.0598*
Marital Status (marr3cat)	3	2.13			*0.1106*
Selenium Intake/RDA (sele2cat)	1	2.44			*0.1255*
Time in Longest Employment (ljt)	2	1.68			*0.1976*
Alcohol Consumption (retohuse)	3	1.60			*0.2020*
Household Size (hsize)	1	1.55			*0.2193*
Serum Cotinine (cot3cat)	2	1.37			*0.2641*
Race-Ethnicity/Hispanic Grouping (race4cat)	3	0.96			*0.4210*

Table 46
Variance Inflation Factor Test for Collinearity Among Independent Variables
using the Best-Fit Logistic Regression Exposure Model (1999-2004)

	df	sum of squares	mean square	F value	pr>F	
Best-Fit Exposure Model *with no interactions*	13	258.99	19.930	113.13	*<0.001*	

Variable Name	df	parameter estimate	std error	t value	pr>t	VIF
Intercept	1	-0.499	0.044	-11.26	*<0.0001*	0.0000
Age (age4cat)	1	0.121	0.005	23.01	*<0.0001*	1.9536
Food Security (food2cat)	1	-0.00009	0.008	-0.01	*0.9907*	1.0376
Selenium Intake/RDA (sele2cat)	1	-0.002	0.011	-0.20	*0.8433*	1.0318
Ever Breastfed (brstfda)	1	-0.032	0.011	-2.94	*0.0033*	1.3960
Fish in Past 30 Days (fish2cat)	1	0.124	0.009	13.22	*<0.0001*	1.1280
Shellfish in Past 30 Days (shell2cat)	1	0.092	0.009	10.46	*<0.0001*	1.1003
Alcohol Consumption (retohuse)	1	0.010	0.006	1.74	*0.0813*	1.2960
Serum Cotinine (cot3cat)	1	0.034	0.005	6.31	*<0.0001*	1.0774
Household Size (hsize)	1	0.001	0.010	0.10	*0.9241*	1.4153
Time in Longest Employment (ljt)	1	0.006	0.006	1.04	*0.2965*	1.0729
Highest Education (educ2)	1	0.008	0.010	0.76	*0.4459*	1.3966
Marital Status (marr3cat)	1	0.025	0.006	4.46	*<0.0001*	1.7699
Race-Ethnicity/Hispanic Grouping (race4cat)	1	0.021	0.005	4.37	*<0.0001*	1.1474

Table 47
Statistical Significance of Interactions Between Independent Variables using the Best-Fit Logistic Regression Exposure Model (1999-2004)

Independent Variables	Age (age4cat)	Food Security (food2cat)	Selenium Intake/RDA (sele2cat)	Ever Breastfed (brstfda)	Fish in Past 30 Days (fish2cat)	Shellfish in Past 30 Days (shell2cat)	Alcohol Consumption (retohuse)	Serum Cotinine (cot3cat)	Household Size (hsize)	Time in Longest Employment (ljt)	Highest Education (educ2)	Marital Status (marr3cat)	Race-Ethnicity Hispanic Grouping (race4cat)
Age (age4cat)													
Food Security (food2cat)	*op*												
Selenium Intake/RDA (sele2cat)	*<0.001*	*ns*											
Ever Breastfed (brstfda)	*ns*	*<0.01*	*<0.01*										
Fish in Past 30 Days (fish2cat)	*<0.001*	*<0.05*	*ns*	*<0.01*									
Shellfish in Past 30 Days (shell2cat)	*<0.001*	*<0.001*	*ns*	*ns*	*ns*								
Alcohol Consumption (retohuse)	*op*	*<0.001*	*<0.05*	*op*	*<0.01*	*<0.001*							
Serum Cotinine (cot3cat)	*<0.001*	*ns*	*<0.001*	*<0.02*	*<0.001*	*<0.05*	*<0.001*						
Household Size (hsize)	*ns*	*<0.01*	*ns*	*<0.001*	*ns*	*<0.001*	*<0.001*	*<0.001*					
Time in Longest Employment (ljt)	*<0.001*	*<0.01*	*ns*	*<0.001*	*<0.001*	*ns*	*<0.001*	*<0.01*	*<0.001*				
Highest Education (educ2)	*<0.001*	*<0.05*	*ns*	*<0.02*	*ns*	*ns*	*<0.01*	*ns*	*<0.05*	*ns*			
Marital Status (marr3cat)	*op*	*op*	*ns*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*op*	*ns*	*<0.001*	*<0.01*		
Race-Ethnicity/Hispanic Grouping (race4cat)	*<0.001*	*op*	*<0.05*	*<0.01*	*<0.001*	*<0.01*	*op*	*op*	*ns*	*<0.001*	*<0.01*	*op*	

op = overparameterized unable to calculate
ns = not statistically significant p>0.05

Table 48
Odds Ratios and Confidence Intervals for Best-Fit Logistic Regression Exposure Model *with no interactions* (1999-2004)

Variable Names	df	-2LL Wald F	*p* value	Odds Ratios	Confidence Intervals
Susceptibility-Related Attributes					
Age (age4cat)	3	11.92	*0.0000*		
16-19[R]				1.00	*ns*
20-29				3.50	1.56 - 7.85
30-39				8.48	3.16 - 22.74
40-49				30.20	8.36 - 109.15
Nutritional Status					
Food Security (food2cat)	2	5.94	*0.0052*		
food secure[R]				1.00	*ns*
food insecure				0.61	0.35 - 1.06
missing				2.38	1.18 - 4.82
Selenium Intake/RDA (sele2cat)	1	2.44	*0.1255*		
recommended or more[R]				1.00	*ns*
less than recommended				0.66	0.39 - 1.13
Reproductive Status					
Ever Breastfed (brstfda)	1	5.32	*0.0258*		
never breastfed[R]				1.00	*ns*
breastfed more than one month or currently				0.56	0.34 - 0.93
Exposure-Related Attributes					
Diet					
Fish Eaten in Past 30 Days (fish2cat)	1	26.26	*0.0000*		
none[R]				1.00	*ns*
any				3.11	1.99 - 4.86
Shellfish Eaten in Past 30 Days (shell2cat)	1	3.73	*0.0598*		
none[R]				1.00	*ns*
any				1.53	0.98 - 2.38
Alcohol Consumption					
Alcohol Consumption (retohuse)	3	1.60	*0.2020*		
never, seldom drinker[R]				1.00	*ns*
drinker				0.66	0.37 - 1.17
heavy drinker				1.20	0.70 - 2.07
missing				1.30	0.57 - 2.99
Tobacco Use					
Serum Cotinine (cot3cat)	2	1.37	*0.2641*		
< 1.0 ng/ml[R]				1.00	*ns*
1.0 - 10.0 ng/ml				0.73	0.26 - 2.09
> 10.0 ng/ml				1.38	0.88 - 2.16
Residence					
Household Size (hsize)	1	1.55	*0.2193*		
four persons or less[R]				1.00	*ns*
more than four persons				0.71	0.41 - 1.23
Occupation					
Time in Longest Employment (ljt)	2	1.68	*0.1976*		
not applicable[R]				1.00	*ns*
less than five years				0.87	0.53 - 1.42
five or more years				1.68	0.90 - 3.13

[R] = referent group
ns = not significant

Table 48
Odds Ratios and Confidence Intervals for Best-Fit Logistic Regression Exposure Model *with no interactions* (1999 - 2004)

Variable Names	df	-2LL Wald F	*p* value	Odds Ratios	Confidence Intervals
Socioeconomic Factors					
Education					
Highest Education (educ2)	1	3.81	*0.0572*		
high school diploma, GED or higher[R]				1.00	*ns*
less than high school diploma				1.96	0.98 - 3.93
Marital Status					
Marital Status (marr3cat)	3	2.13	*0.1106*		
married or living with partner				0.93	0.57 - 1.53
widowed, divorced or separated				1.17	0.58 - 2.34
never married[R]				1.00	*ns*
missing				5.11	1.18 - 22.26
Race-Ethnicity					
Race-Ethnicity/Hispanic Grouping (race4cat)	3	0.96	*0.4210*		
Non-Hispanic White[R]				1.00	*ns*
Non-Hispanic Black				1.08	0.56 - 2.11
Hispanic				0.67	0.39 - 1.15
Asian, Native American, Pacific Islander & Multi-Racial				0.59	0.15 - 2.32

[R] = referent group
ns = not significant

Table 49
Bivariate Analyses of Independent Variables on Lead Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Susceptibility-Related Attributes						
Age (age4cat)						
16-19[R]	654.00 (39.66%) 12,999,734.19 (18.97%)		431.00 (28.28%) 5,510,734.53 (8.35%)			
20-29	558.00 (33.84%) 29,716,727.03 (43.36%)		326.00 (21.39%) 15,630,787.88 (23.69%)		229.84 *<0.0001*	9.12 *0.0001*
30-39	307.00 (18.62%) 16,135,631.99 (23.55%)		395.00 (25.92%) 20,222,204.52 (30.65%)			
40-49	130.00 (7.88%) 9,676,562.19 (14.12%)		372.00 (24.41%) 24,609,651.11 (37.30%)			
Health Status						
Perceived Health Status (huq2cat)						
excellent, very good, good[R]	1,537.00 (93.21%) 65,500,225.53 (95.58%)		1,303.00 (85.55%) 58,505,019.56 (88.72%)		49.49 *<0.0001*	15.58 *0.0003*
fair, poor	112.00 (6.79%) 3,028,429.87 (4.42%)		220.00 (14.45%) 7,437,449.73 (11.28%)			
Charleson Co-Morbidity Scale (CCMS3cat)						
none[R]	1,466.00 (88.90%) 60,632,812.02 (88.48%)		1,348.00 (88.45%) 57,624,209.41 (87.34%)			
one co-morbidity	164.00 (9.95%) 6,883,909.15 (10.05%)		139.00 (9.12%) 6,262,824.16 (9.49%)		7.88 *0.019*	0.89 *0.415*
more than one co-morbidity	* (0.00%) 1,011,934.23 (1.48%)		37.00 (2.43%) 2,086,344.46 (3.16%)			
Iron Deficiency (FeD2cat)						
within normal limits[R]	1,444.00 (87.57%) 63,102,828.80 (92.08%)		1,280.00 (83.99%) 59,733,929.83 (90.54%)		8.35 *0.004*	0.57 *0.453*
iron deficient	205.00 (12.43%) 5,425,826.61 (7.92%)		244.00 (16.01%) 6,239,448.20 (9.46%)			
Treatment for Iron Deficiency past 3 mo (FeTx2cat)						
yes	87.00 (5.28%) 2,760,932.98 (4.03%)		84.00 (5.52%) 2,385,362.99 (3.62%)		0.09 *0.765*	0.13 *0.719*
no[R]	1,562.00 (94.72%) 65,767,722.42 (95.97%)		1,439.00 (94.48%) 63,574,435.97 (96.38%)			

Table 49
Bivariate Analyses of Independent Variables on Lead Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Iron Deficiency and Treatment (FeDTx)						
normal/no treatment[R]	1,384.00 (83.93%) 61,488,181.97 (89.73%)		1,224.00 (80.37%) 57,954,516.72 (87.86%)			
normal w/treatment	60.00 (3.64%) 1,614,646.83 (2.36%)		55.00 (3.61%) 1,765,834.04 (2.68%)		8.59 *0.035*	1.11 *0.355*
deficient w/treatment	* (0.00%) 1,146,286.15 (1.67%)		* (0.00%) 619,528.95 (0.94%)			
deficient/no treatment	178.00 (10.79%) 4,279,540.45 (6.24%)		215.00 (14.12%) 5,619,919.25 (8.52%)			
Health Insurance (hi2cat)						
private[R]	1,190.00 (72.16%) 55,923,021.64 (81.61%)		852.00 (55.91%) 44,209,756.83 (67.01%)			
public	202.00 (12.25%) 3,486,900.48 (5.09%)		237.00 (15.55%) 6,304,519.60 (9.56%)		104.60 *<0.0001*	5.47 *0.0028*
none	221.00 (13.40%) 7,704,122.50 (11.24%)		398.00 (26.12%) 14,058,681.86 (21.31%)			
missing	36.00 (2.18%) 1,414,610.78 (2.06%		37.00 (2.43%) 1,400,419.73 (2.12%)			
Regular Source of Healthcare (hp2cat)						
yes[R]	1,393.00 (84.48%) 57,510,193.88 (83.92%)		1,280.00 (83.99%) 57,948,088.45 (87.84%)		0.14 *0.707*	0.57 *0.454*
no	256.00 (15.52%) 11,018,461.53 (16.08%)		244.00 (16.01%) 8,025,289.58 (12.16%)			
Source of Healthcare (hcsre)						
healthcare provider[R]	981.00 (59.49%) 42,334,589.32 (61.78%)		826.00 (54.20%) 42,827,250.68 (64.92%)			
clinic	319.00 (19.35%) 11,550,404.67 (16.85%)		357.00 (23.43%) 12,217,692.20 (18.52%)		10.88 *0.012*	0.25 *0.859*
ER or none	323.00 (19.59%) 13,205,152.16 (19.27%)		319.00 (20.93%) 9,757,504.60 (14.79%)			
missing	26.00 (1.58%) 1,438,509.25 (2.10%)		22.00 (1.44%) 1,170,930.55 (1.77%)			

Table 49
Bivariate Analyses of Independent Variables on Lead Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Nutritional Status						
Food Security (food2cat)						
food secure[R]	1,373.00 (83.26%) 59,441,670.08 (86.74%)		1,199.00 (78.67%) 54,602,242.59 (82.76%)			
food insecure	211.00 (12.80%) 6,584,798.88 (9.61%)		248.00 (16.27%) 7,649,723.16 (11.60%)		10.86 *0.004*	0.94 *0.398*
missing	65.00 (3.94%) 2,502,186.44 (3.65%)		77.00 (5.05%) 3,721,412.28 (5.64%)			
Body Mass Index (bmi30cat)						
<30.0[R] underweight normal overweight	1,229.00 (74.53%) 52,465,286.32 (76.56%)		1,128.00 (74.02%) 50,378,610.60 (76.36%)			
30.0+ obese	394.00 (23.89%) 15,255,751.26 (22.26%)		383.00 (25.13%) 14,960,706.54 (22.68%)		3.89 *0.142*	0.05 *0.954*
missing	26.00 (1.58%) 807,617.82 (1.18%)		13.00 (0.85%) 634,060.89 (0.96%)			
Fat Intake/AMDR (fat3cat)						
recommended or less[R]	1,041.00 (63.13%) 41,953,958.29 (61.22%)		1,007.00 (66.25%) 44,725,757.50 (67.93%)			
more than recommended	608.00 (36.87%) 26,574,697.11 (38.78%)		513.00 (33.75%) 21,117,948.89 (32.07%)		3.37 *0.066*	3.46 *0.069*
Protein Intake/AMDR (prot3cat)						
recommended or more[R]	1,456.00 (88.30%) 61,807,745.82 (90.19%)		1,256.00 (82.41%) 56,956,019.45 (86.33%)			
less than recommended	193.00 (11.70%) 6,720,909.58 (9.81%)		268.00 (17.59%) 9,017,358.58 (13.67%)		22.06 *<0.0001*	2.41 *0.127*
Iron Intake/RDA (iron2cat)						
recommended or more[R]	1,362.00 (82.60%) 56,771,475.34 (82.84%)		1,152.00 (75.59%) 50,670,842.64 (76.80%)			
less than recommended	287.00 (17.40%) 11,757,180.06 (17.16%)		372.00 (24.41%) 15,302,535.39 (23.20%)		23.62 *<0.0001*	3.14 *0.083*
Calcium Intake/RDA (calc2cat)						
recommended or more[R]	390.00 (23.65%) 14,461,237.96 (21.10%)		250.00 (16.40%) 11,615,071.24 (17.61%)			
less than recommended	1,259.00 (76.35%) 54,067,417.44 (78.90%)		1,274.00 (83.60%) 54,358,306.79 (82.39%)		25.83 *<0.0001*	0.66 *0.420*

Table 49
Bivariate Analyses of Independent Variables on Lead Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Selenium Intake/RDA (sele2cat)						
recommended or more[R]	1,372.00 (83.20%) 58,048,368.20 (84.71%)		1,185.00 (77.76%) 54,597,023.61 (82.76%)		15.01 *0.0001*	0.33 *0.567*
less than recommended	277.00 (16.80%) 10,480,287.20 (15.29%)		339.00 (22.24%) 11,376,354.42 (17.24%)			
Reproductive Status						
Current Pregnancy (pregnant)						
pregnant	260.00 (15.77%) 3,622,017.44 (5.29%)		131.00 (8.60%) 1,220,171.65 (1.85%)			
not pregnant[R]	1,314.00 (79.68%) 62,923,534.24 (91.82%)		1,327.00 (87.07%) 63,452,984.69 (96.18%)		38.33 *<0.0001*	6.49 *0.003*
missing	75.00 (4.55%) 1,983,103.72 (2.89%)		66.00 (4.33%) 1,300,221.69 (1.97%)			
Trimester of Pregnancy (tripcorr)						
not pregnant[R]	1,389.00 (84.23%) 64,906,637.96 (94.71%)		1,393.00 (91.40%) 64,753,206.38 (98.15%)			
1st trimester	88.00 (5.34%) 1,429,778.42 (2.09%)		61.00 (4.00%) 561787.69 (0.85%)		43.35 *<0.0001*	4.18 *0.0108*
2nd trimester	96.00 (5.82%) 1,183,077.47 (1.73%)		36.00 (2.36%) 340,418.06 (0.52%)			
3rd trimester	76.00 (4.61%) 1,009,161.55 (1.47%)		34.00 (2.23%) 317,965.89 (0.48%)			
Ever Pregnant (tprg2cat)						
never pregnant[R]	926.00 (56.16%) 38,526,860.71 (56.22%)		609.00 (39.96%) 21,038,236.27 (31.89%)		83.17 *<0.0001*	12.20 *0.0011*
one or more pregnancies	723.00 (43.84%) 30,001,794.69 (43.78%)		915.00 (60.04%) 44,935,141.76 (68.11%)			
Live Births (live)						
no live births[R]	1,079.00 (65.43%) 42,276,920.40 (61.69%)		741.00 (48.62%) 25,143,317.82 (38.11%)		91.52 *<0.0001*	11.67 *0.0014*
one or more live births	570.00 (34.57%) 26,251,735.00 (38.31%)		783.00 (51.38%) 40,830,060.21 (61.89%)			
Ever Breastfed (brstfda)						
never breastfed[R]	1,275.00 (77.32%) 50,391,371.75 (73.53%)		1,048.00 (68.77%) 41,562,950.55 (63.00%)		29.54 *<0.0001*	4.89 *0.032*
breastfed more than one month or currently	374.00 (22.68%) 18,137,283.65 (26.47%)		476.00 (31.23%) 24,410,427.48 (37.00%)			

Table 49
Bivariate Analyses of Independent Variables on Lead Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Exposure-Related Attributes						
Acculturation						
Birthplace (born2cat)						
U.S.[R]	1,513.00 (91.75%) 63,840,566.10 (93.16%)		1,160.00 (76.12%) 56,463,130.70 (85.58%)		145.89 *<0.0001*	7.61 *0.0084*
outside U.S.	136.00 (8.25%) 4,688,089.30 (6.84%)		364.00 (23.88%) 9,510,247.33 (14.42%)			
Years in U.S. (yrus5)						
born in U.S.[R]	1,513.00 (91.75%) 63,840,566.10 (93.16%)		1,160.00 (76.42%) 56,463,130.70 (85.80%)		149.07 *<0.0001*	8.05 *0.001*
five or more years	111.00 (6.73%) 4,165,110.26 (6.08%)		241.00 (15.88%) 6,908,408.95 (10.50%)			
less than five years	* (0.00%) 522,979.04 (0.76%)		117.00 (7.71%) 2,432,987.87 (3.70%)			
Language Spoken at Home (lang2cat)						
English[R]	1,575.00 (95.63%) 66,327,561.13 (97.11%)		1,269.00 (83.27%) 60,433,633.23 (91.60%)		130.76 *<0.0001*	15.45 *0.0003*
Other	72.00 (4.37%) 1,974,026.91 (2.89%)		255.00 (16.73%) 5,539,744.80 (8.40%)			
U.S. Citizenship (usczn2cat)						
U.S. citizen[R]	1,581.00 (95.88%) 67,122,982.83 (97.95%)		1,233.00 (80.96%) 59,702,289.08 (90.52%)		175.97 *<0.0001*	20.42 *0.0000*
non-U.S. citizen	68.00 (4.12%) 1,405,672.57 (2.05%)		290.00 (19.04%) 6,249,220.26 (9.48%)			
Diet						
Seafood Eaten in Past 30 Days (smpw2cat)						
none[R]	384.00 (23.29%) 12,454,300.40 (18.17%)		302.00 (19.82%) 10,416,540.38 (15.79%)		5.63 *0.018*	0.68 *0.414*
any	1,265.00 (76.71%) 56,074,355.00 (81.83%)		1,222.00 (80.18%) 55,556,837.65 (84.21%)			
Fish Eaten in Past 30 Days (fish2cat)						
none[R]	560.00 (33.96%) 19,647,726.77 (28.67%)		480.00 (31.50%) 17,162,012.91 (26.01%)		2.18 *0.139*	0.71 *0.404*
any	1,089.00 (66.04%) 48,880,928.64 (71.33%)		1,044.00 (68.50%) 48,811,365.12 (73.99%)			

Table 49
Bivariate Analyses of Independent Variables on Lead Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Shellfish Eaten in Past 30 Days (shell2cat)						
none[R]	858.00 (52.03%) 34,676,194.15 (50.60%)		699.00 (45.87%) 28,342,445.03 (42.96%)		12.05 *0.0005*	1.72 *0.197*
any	791.00 (47.97%) 33,852,461.25 (49.40%)		825.00 (54.13%) 37,630,933.00 (57.04%)			
Tap Water Consumed Prior 24h (tap2kct)						
none[R]	614.00 (37.23%) 21,450,765.92 (31.30%)		515.00 (33.79%) 1,9054,062.33 (28.88%)			
< 2,000 ml	804.00 (48.76%) 37,062,060.55 (54.08%)		734.00 (48.16%) 33,983,424.87 (51.51%)		18.43 *0.0004*	0.87 *0.465*
2,000+ ml	150.00 (9.10%) 7,062,800.32 (10.31%)		145.00 (9.51%) 8,466,752.18 (12.83%)			
missing	81.00 (4.91%) 2,953,028.61 (4.31%)		130.00 (8.53%) 4,469,138.66 (6.77%)			
Alcohol Consumption						
Alcohol Consumption (retohuse)						
never, seldom drinker[R] *including 16-19 y/o*	954.00 (57.85%) 30,947,002.42 (45.16%)		789.00 (51.77%) 21,273,512.95 (32.25%)			
drinker	393.00 (23.83%) 20,442,176.43 (29.83%)		337.00 (22.11%) 20,227,903.14 (30.66%)		32.76 *<0.0001*	2.17 *0.104*
heavy drinker	228.00 (13.83%) 14,365,946.82 (20.96%)		327.00 (21.46%) 21,399,432.62 (32.44%)			
missing	74.00 (4.49%) 2,773,529.73 (4.05%)		71.00 (4.66%) 3,072,529.32 (4.66%)			
Tobacco Use						
Serum Cotinine (cot3cat)						
< 1.0 ng/ml[R]	1,373.00 (83.72%) 57,274,884.18 (83.94%)		995.00 (65.55%) 41,596,589.39 (63.37%)			
1.0 - 10.0 ng/ml	79.00 (4.82%) 2,665,982.02 (3.91%)		111.00 (7.31%). 2,584,319.60 (3.94%)		144.86 *<0.0001*	9.52 *0.0004*
> 10.0 ng/ml	188.00 (11.46%) 8,289,862.88 (12.15%)		412.00 (27.14%) 21,460,478.36 (32.69%)			

Table 49
Bivariate Analyses of Independent Variables on Lead Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
ETS (ETS)						
no ETS[R]	1,303.00 (79.02%) 55,492,798.64 (80.98%)		1,114.00 (73.10%) 46,304,572.94 (70.19%)			
ETS at home or work	296.00 (17.95%) 10,918,510.24 (15.93%)		354.00 (23.23%) 15,788,359.36 (23.93%)		15.39 *0.0005*	3.19 *0.051*
ETS at home and work	50.00 (3.03%) 2,117,346.52 (3.09%)		56.00 (3.67%) 3,880,445.73 (5.88%)			
Residence						
Tap Water Source (h2os2cat)						
public[R]	1,444.00 (87.57%) 59,518,100.62 (86.85%)		1,382.00 (90.68%) 57,217,807.54 (86.73%)			
private	170.00 (10.31%) 7,567,628.68 (11.04%)		96.00 (6.30%) 6,923,906.34 (10.50%)		18.55 *<0.0001*	0.19 *0.827*
missing	35.00 (2.12%) 1,442,926.10 (2.11%)		46.00 (3.02%) 1,831,664.14 (2.78%)			
Residential Tap Water Treatment (h2ox2cat)						
yes	519.00 (31.47%) 24,424,707.57 (35.64%)		344.00 (22.57%) 20,883,527.10 (31.65%)			
no[R]	1,096.00 (66.46%) 42,669,608.13 (62.27%)		1,143.00 (75.00%) 43,875,729.23 (66.51%)		31.73 *<0.0001*	0.25 *0.779*
missing	34.00 (2.06%) 1,434,339.70 (2.09%)		37.00 (2.43%) 1,214,121.70 (1.84%)			
Type of Residence (res3cat)						
attached or detached house[R]	1,090.00 (66.10%) 44,740,021.12 (65.29)		982.00 (64.44%) 44,565,949.44 (67.55%)			
mobile home or trailer	82.00 (4.97%) 2,426,410.42 (3.54%)		120.00 (7.87%) 5,975,367.38 (9.06%)		11.24 *0.003*	3.72 *0.032*
all other types *including missing/unknown*	477.00 (28.93%) 21,362,223.86 (31.17%)		422.00 (27.69%) 15,432,061.21 (23.39%)			
Age of Residence (resb60cat)						
1960 or newer[R]	958.00 (58.10%) 43,391,502.90 (63.32%)		637.00 (41.80%) 34,653,021.12 (52.53%)			
older than 1960	382.00 (23.17%) 15,705,459.67 (22.92%)		384.00 (25.20%) 16,386,740.43 (24.84%)		106.19 *<0.0001*	3.34 *0.045*
missing/unknown	309.00 (18.74%) 9,431,692.83 (13.76%)		503.00 (33.01%) 14,933,616.49 (22.64%)			

Table 49
Bivariate Analyses of Independent Variables on Lead Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Age of Residence (resb78cat)						
1978 or newer[R]	639.00 (38.75%) 30,166,573.45 (44.02%)		448.00 (29.40%) 25,221,475.40 (38.23%)			
older than 1978	701.00 (42.51%) 28,930,389.12 (42.22%)		573.00 (37.60%) 25,818,286.14 (39.13%)		87.98 *<0.0001*	2.24 *0.118*
missing/unknown	309.00 (18.74%) 9,431,692.83 (13.76%)		503.00 (33.01%) 14,933,616.49 (22.64%)			
Resident Status (resd3cat)						
own[R]	936.00 (56.76%) 37,822,046.75 (55.19%)		791.00 (51.90%) 39,428,260.38 (59.76%)			
rent	619.00 (37.54%) 27,252,592.24 (39.77%)		659.00 (43.24%) 23,911,303.33 (36.24%)		10.89 *0.004*	0.50 *0.608*
other *including missing*	94.00 (5.70%) 3,454,016.42 (5.04%)		74.00 (4.86%) 2,633,814.32 (3.99%)			
Years at Current Residence (re5yrcat)						
more than five years[R]	560.00 (33.96%) 21,445,224.57 (31.29%)		553.00 (36.29%) 24,449,094.12 (37.06%)			
five years or less	1,067.00 (64.71%) 46,043,199.30 (67.19%)		940.00 (61.68%) 40,412,413.64 (61.26%)		4.69 *0.090*	0.92 *0.407*
missing	22.00 (1.33%) 1,040,231.53 (1.52%)		31.00 (2.03%) 1,111,870.27 (1.69%)			
Household Size (hsize)						
four persons or less[R]	1,170.00 (70.95%) 54,111,047.44 (78.96%)		1,012.00 (66.40%) 52,342,980.95 (79.34%)			
more than four persons	479.00 (29.05%) 14,417,607.96 (21.04%)		512.00 (33.60%) 13,630,397.08 (20.66%)		7.63 *0.005*	0.01 *0.917*
Rooms in Residence (rm3cat)						
7+ rooms[R]	658.00 (39.90%) 27,588,606.15 (40.26%)		490.00 (32.15%) 25,027,906.66 (37.94%)			
4-6 rooms	823.00 (49.91%) 33,258,195.04 (48.53%)		868.00 (56.96%) 35,841,937.55 (54.33%)		20.91 *0.0001*	0.78 *0.508*
1-3 rooms	132.00 (8.00%) 6,188,856.51 (9.03%)		131.00 (8.60%) 3,986,316.60 (6.04%)			
missing	36.00 (2.18%) 1492997.69 (2.18%)		35.00 (2.30%) 1,117,217.23 (1.69%)			

Table 49
Bivariate Analyses of Independent Variables on Lead Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Occupation						
Current Occupation (cocc2cat)						
not working[R]	662.00 (40.15%) 19,925,730.66 (29.08%)		662.00 (43.44%) 22,247,226.92 (33.72%)			
management, professional & sales	699.00 (42.39%) 34,344,959.83 (50.12%)		544.00 (35.70%) 33,413,931.91 (50.65%)		15.91 *0.0004*	1.11 *0.339*
services & goods	288.00 (17.47%) 14,257,964.91 (20.81%)		318.00 (20.87%) 10,312,219.21 (15.63%)			
Time in Current Employment (cjt)						
not working[R]	662.00 (40.15%) 1,992,730.66 (29.08%)		662.00 (43.44%) 22,247,226.92 (33.72%)			
less than five years	819.00 (49.67%) 39,135,012.39 (57.11%)		615.00 (40.35%) 28,106,627.34 (42.60%)		39.19 *<0.0001*	3.39 *0.043*
five or more years	168.00 (10.19%) 9,467,912.35 (13.82%)		247.00 (16.21%) 15,619,523.77 (23.68%)			
Total Hours Worked Prior Week (hrwk)						
not employed[R]	687.00 (41.69%) 21,100,851.66 (30.85%)		694.00 (45.57%) 24,707,186.37 (37.46%)			
less than 35 hours	424.00 (25.73%) 19,069,618.35 (27.88%)		312.00 (20.49%) 14,297,815.45 (21.68%)		12.55 *0.019*	2.47 *0.096*
35+ hours	537.00 (32.58%) 28,235,013.48 (41.28%)		517.00 (33.95%) 26,946,507.53 (40.86%)			
Longest Held Occupation (locc2cat)						
not applicable[R]	789.00 (47.85%) 31,338,831.82 (45.73%)		773.00 (50.72%) 32,778,524.69 (49.68%)			
management, professional & sales	464.00 (28.14%) 20,407,781.11 (29.78%)		439.00 (28.81%) 21,007,405.04 (31.84%)		5.91 *0.05*	0.48 *0.623*
services & goods	396.00 (24.01%) 16,782,042.47 (24.49%)		312.00 (20.47%) 12,187,448.30 (18.47%)			
Time in Longest Employment (ljt)						
not applicable[R]	789.00 (47.85%) 31,338,831.82 (45.73%)		773.00 (50.72%) 32,778,524.69 (49.68%)			
less than five years	565.00 (34.26%) 19,352,964.01 (28.24%)		432.00 (28.35%) 15,189,304.84 (23.02%)		13.94 *0.0009*	0.67 *0.517*
five or more years	295.00 (17.89%) 17,836,859.57 (26.03%)		319.00 (20.93%) 18,005,548.50 (27.29%)			

Table 49
Bivariate Analyses of Independent Variables on Lead Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Socioeconomic Factors						
Education						
Highest Education (educ2)						
high school diploma, GED or higher[R]	1,096.00 (66.46%) 54,561,650.03 (79.62%)		941.00 (61.79%) 52,345,511.31 (79.42%)		7.54 *0.006*	0.001 *0.973*
less than high school diploma	553.00 (33.54%) 13,967,005.37 (20.38%)		582.00 (38.21%) 13,560,727.93 (20.58%)			
Employment						
Employment Status (emp3cat)						
employed	988.00 (59.99%) 48,624,413.53 (70.97%)		865.00 (56.76%) 43,844,386.43 (66.46%)		3.39 *0.065*	1.39 *0.244*
not employed[R]	659.00 (40.01%) 19,893,022.35 (29.03%)		659.00 (43.24%) 22,128,991.60 (33.54%)			
Reason for Unemployment (unem2cat)						
working[R]	988.00 (59.92%) 48,624,413.53 (70.95%)		865.00 (56.76%) 43,844,386.43 (66.46%)		29.80 *<0.0001*	2.65 *0.060*
voluntary unemployment	466.00 (28.26%) 14,209,493.25 (20.74%)		458.00 (30.05%) 14,055,528.43 (21.30%)			
involuntary unemployment	123.00 (7.46%) 3,277,577.66 (4.78%)		172.00 (11.29%) 6,985,536.35 (10.59%)			
missing	72.00 (4.37%) 2,417,170.97 (3.53%)		29.00 (1.90%) 1,087,926.82 (1.65%)			
Work History (wkcp)						
never employed[R]	190.00 (11.52%) 3,194,843.15 (4.66%)		218.00 (14.30%) 5,043,967.65 (7.65%)		8.98 *0.029*	1.13 *0.348*
currently employed	599.00 (36.33%) 28,143,988.67 (41.07%)		555.00 (36.42%) 27,734,557.04 (42.04%)			
employed in the past but not currently	472.00 (28.62%) 16,730,887.51 (24.41%)		444.00 (29.13%) 17,203,259.27 (26.08%)			
employed now and in the past	388.00 (23.53%) 20,458,936.07 (29.85%)		307.00 (20.14%) 15,991,594.07 (24.24%)			

Table 49
Bivariate Analyses of Independent Variables on Lead Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Income						
U.S. Poverty Threshold (pov2cat)						
more than 1.00^{R}	1,237.00 (75.02%) 52,645,984.77 (76.82%)		990.00 (64.96%) 51,307,638.42 (77.77%)		43.72 *<0.0001*	0.45 *0.641*
1.00 or less	333.00 (20.19%) 12,438,247.06 (18.15%)		397.00 (26.05%) 10,148,950.41 (15.38%)			
missing	79.00 (4.79%) 3,444,423.57 (5.03%)		137.00 (8.99%) 4,516,789.20 (6.85%)			
Marital Status						
Marital Status (marr3cat)						
married or living with partner	567.00 (34.38%) 26,626,378.49 (38.85%)		631.00 (41.40%) 35,174,269.76 (53.32%)		82.89 *<0.0001*	9.23 *0.0001*
widowed, divorced or separated	86.00 (5.22%) 4,130,631.35 (6.03%)		175.00 (11.48%) 10,223,321.03 (15.50%)			
never married^{R}	964.00 (58.46%) 36,238,595.44 (52.88%)		673.00 (44.16%) 17,254,356.05 (26.15%)			
missing	32.00 (1.94%) 1,533,050.12 (2.24%)		45.00 (2.95%) 3,321,431.19 (5.03%)			
Race-Ethnicity						
Race-Ethnicity (race5cat)						
Non-Hispanic White^{R}	899.00 (54.52%) 52,707,454.40 (76.91%)		594.00 (38.98%) 45,180,089.76 (68.48%)		84.47 *<0.0001*	5.12 *0.0018*
Non-Hispanic Black	258.00 (15.65%) 4,619,603.97 (6.74%)		365.00 (23.95%) 8,127,574.39 (12.32%)			
Mexican American	333.00 (20.19%) 3,455,944.04 (5.04%)		412.00 (27.03%) 5,214,631.76 (7.90%)			
Other Hispanic	92.00 (5.58%) 4,332,333.00 (6.32%)		86.00 (5.64%) 3,193,659.22 (4.84%)			
Asian, Native American, Pacific Islander & Multi-Racial	67.00 (4.06%) 3,413,319.99 (4.98%)		67.00 (4.40%) 4,257,422.89 (6.45%)			

Table 49
Bivariate Analyses of Independent Variables on Lead Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Race-Ethnicity/Hispanic Grouping (race4cat)						
Non-Hispanic White^{R}	899.00 (54.52%) 52,707,454.40 (76.91%)		594.00 (38.98%) 45,180,089.76 (68.48%)			
Non-Hispanic Black	258.00 (15.65%) 4,619,603.97 (6.74%)		365.00 (23.95%) 8,127,574.39 (12.32%)		81.66 *<0.0001*	5.08 *0.004*
Hispanic	425.00 (25.77%) 7,788,277.04 (11.36%)		498.00 (32.68%) 8,408,290.98 (12.74%)			
Asian, Native American, Pacific Islander & Multi-Racial	67.00 (4.06%) 3,413,319.99 (4.98%)		67.00 (4.40%) 4,257,422.89 (6.45%)			

Table 50

Summary of Chi-Square (χ^2) and *p* Values of Weighted Independent Variables on Lead (1999-2004)

Variables *p < 0.20*	*p* value	χ^2 *weighted*	Variables *p > 0.20*	*p* value	χ^2 *weighted*
U.S. Citizenship (usczn2cat)	*0.0000*	20.42	Employment Status (emp3cat)	*0.244*	1.39
Marital Status (marr3cat)	*0.0001*	9.23	Current Occupation (cocc2cat)	*0.339*	1.11
Age (age4cat)	*0.0001*	9.12	Work History (wkcp)	*0.348*	1.13
Perceived Health Status (huq2cat)	*0.0003*	15.58	Iron Deficiency and Treatment (FeDTx)	*0.355*	1.11
Language Spoken at Home (lang2cat)	*0.0003*	15.45	Food Security (food2cat)	*0.398*	0.94
Serum Cotinine (cot3cat)	*0.0004*	9.52	Fish in Past 30 Days (fish2cat)	*0.404*	0.71
Years in U.S. (yrus5)	*0.001*	8.05	Years at Current Residence (re5yrcat)	*0.407*	0.92
Ever Pregnant[1] (tprg2cat)	*0.0011*	12.20	Seafood in Past 30 Days [1] (smpw2cat)	*0.414*	0.68
Live Births (live)	*0.0014*	11.67	Calcium Intake/RDA (calc2cat)	*0.420*	0.66
Race-Ethnicity[1] (race5cat)	*0.0018*	5.12	Iron Deficiency (FeD2cat)	*0.453*	0.57
Health Insurance (hi2cat)	*0.0028*	5.47	Regular Source of Healthcare (hp2cat)	*0.454*	0.57
Current Pregnancy (pregnant)	*0.003*	6.49	Tap Water Consumed 24h (tap2kct)	*0.465*	0.87
Race-Ethnicity/Hispanic Grouping (race4cat)	*0.004*	5.08	Rooms in Residence (rm3cat)	*0.508*	0.78
Birthplace[1] (born2cat)	*0.0084*	7.61	Time in Longest Employment (ljt)	*0.517*	0.67
Trimester of Pregnancy[1] (tripcorr)	*0.0108*	4.18	Selenium Intake/RDA (sele2cat)	*0.567*	0.33
Ever Breastfed (brstfda)	*0.032*	4.89	Resident Status (resd3cat)	*0.608*	0.50
Type of Residence (res3cat)	*0.032*	3.72	Longest Held Occupation (locc2cat)	*0.623*	0.48
Charleson Co-Morbidity Scale (CCMS3cat)	*0.0415*	0.89	U.S. Poverty Threshold (pov2cat)	*0.641*	0.45
Time in Current Employment (cjt)	*0.043*	3.39	Treatment for Iron Deficiency past 3 mo (FeTx2cat)	*0.719*	0.13
Age of Residence 1960 (resb60cat)	*0.045*	3.34	Residential Tap Water Treatment (h2ox2cat)	*0.779*	0.25
Environmental Tobacco Smoke (ETS)	*0.051*	3.19	Tap Water Source (h2os2cat)	*0.827*	0.19
Reason for Unemployment (unem2cat)	*0.060*	2.65	Source of Healthcare (hscre)	*0.859*	0.25
Fat Intake/AMDR[1] (fat3cat)	*0.069*	3.46	Household Size (hsize)	*0.917*	0.01
Iron Intake/RDA (iron2cat)	*0.083*	3.14	Body Mass Index (bmi30cat)	*0.954*	0.05
Total Hours Worked Prior Week (hrwk)	*0.096*	2.47	Highest Education (educ2)	*0.973*	0.001
Alcohol Consumption (retohuse)	*0.104*	2.17			
Age of Residence (resb78cat)	*0.118*	2.24			
Protein Intake/AMDR[1] (prot3cat)	*0.127*	2.41			
Shellfish in Past 30 Days[1] (shell2cat)	*0.197*	1.72			

[1]variable dropped due to low cell size or too similar to other variables

Table 51
Stepwise Regression Analyses of Lead (1999-2004)

Variable Name *p <0.20*	df	-2LL Wald F	Difference	df	*p* value
Initial Regression	43	989.03			
1 Total Hours Worked Prior Week (hrwk)	41	982.83	6.20	2	*<0.05* *keep*
2 Reason for Unemployment (unem2cat)	40	982.23	6.80	3	*>0.05* *drop*
3 Language Spoken at Home (lang2cat)	39	979.45	2.88	1	*>0.05* *drop*
4 Ever Breastfed (brstfda)	38	978.68	0.77	1	*>0.20* *drop*
5 Charleson Co-Morbidity Scale (CCMS3cat)	36	969.95	8.73	2	*<0.02* *keep*
6 Environmental Tobacco Smoke (ETS)	36	974.50	4.18	2	*>0.05* *drop*
7 Perceived Health Status (huq2cat)	35	974.63	0.13	1	*>0.20* *drop*
8 Time in Current Employment (cjt)	33	961.77	12.86	2	*<0.01* *keep*
9 Iron Intake/RDA (iron2cat)	34	971.65	2.95	1	*>0.05* *drop*
10 Live Births (live)	33	968.97	2.68	1	*>0.10* *drop*
11 Years in U.S. (yrus5)	31	965.55	3.42	2	*>0.10* *drop*
12 Type of Residence (res3cat)	29	951.13	14.42	2	*<0.001* *keep*
13 Protein Intake/AMDR (prot3cat)	30	953.24	12.31	1	*<0.001* *keep*
14 Race-Ethnicity/Hispanic Grouping (race4cat)	28	935.33	30.22	3	*<0.001* *keep*
15 Marital Status (marr3cat)	28	927.02	38.53	3	*<0.001* *keep*
16 Age of Residence 1960 (resb60cat)	29	912.81	52.74	2	*<0.001* *keep*
17 Serum Cotinine (cot3cat)	29	906.75	58.80	2	*<0.001* *keep*
18 Alcohol Consumption (retohuse)	28	879.18	86.37	3	*<0.001* *keep*
19 U.S. Citizenship (usczn2cat)	30	879.17	86.38	1	*<0.001* *keep*
20 Current Pregnancy (pregnant)	29	940.52	25.03	2	*<0.001* *keep*
21 Health Insurance (hi2cat)	28	920.86	44.69	3	*<0.001* *keep*
22 Age (age4cat)	28	826.37	139.18	3	*<0.001* *keep*

Table 52
Best-Fit Logistic Regression Lead Model *with no interactions* (1999-2004)

Variable Name	df	-2LL Wald F	R^2		*p* value
Best Fit Regression	31	965.55	*0.2636*		
U.S. Citizenship (usczn2cat)	1	29.11			*0.0000*
Age (age4cat)	3	6.12			*0.0014*
Age of Residence 1960 (resb60cat)	2	6.26			*0.0041*
Serum Cotinine (cot3cat)	2	5.16			*0.0097*
Health Insurance (hi2cat)	3	4.18			*0.0109*
Current Pregnancy (pregnant)	2	4.96			*0.0114*
Alcohol Consumption (retohuse)	3	3.59			*0.0209*
Race-Ethnicity/Hispanic Grouping (race4cat)	3	3.36			*0.0269*
Marital Status (marr3cat)	3	2.29			*0.0917*
Protein Intake/AMDR (prot3cat)	1	1.92			*0.1727*
Type of Residence (res3cat)	2	1.62			*0.2089*
Time in Current Employment (cjt)	2	0.97			*0.3877*
Charleson Co-Morbidity Scale (CCMS3cat)	2	0.44			*0.6481*
Total Hours Worked Prior Week (hrwk)	2	0.20			*0.8160*

[1] in ascending order by p value

Table 53
Variance Inflation Factor Test for Collinearity Among Independent Variables using the Best-Fit Logistic Regression Lead Model (1999-2004)

	df	sum of squares	mean square	F value	pr>F	
Best-Fit Lead Model *with no interactions*	14	1121.85	80.132	442.98	*<0.001*	

Variable Name	df	parameter estimate	std error	t value	pr>t	VIF
Intercept	1	-0.758	0.031	*-24.36*	*<0.0001*	0.0000
Age (age4cat)	1	0.117	0.004	30.73	*<0.0001*	2.1871
Charleson Co-Morbidity Scale (CCMS3cat)	1	-0.017	*0.008*	-2.16	*0.0308*	1.0241
Health Insurance (hi2cat)	1	0.053	*0.004*	14.54	*<0.0001*	1.1648
Protein Intake/AMDR (prot3cat)	1	0.009	*0.008*	1.05	*0.2943*	1.0254
Current Pregnancy (pregnant)	1	0.218	*0.005*	42.67	*<0.0001*	1.1099
U.S. Citizenship (usczn2cat)	1	0.198	*0.010*	20.19	*<0.0001*	1.2777
Alcohol Consumption (retohuse)	1	0.021	*0.004*	5.39	*<0.0001*	1.4341
Serum Cotinine (cot3cat)	1	0.091	*0.004*	25.55	*<0.0001*	1.1252
Age of Residence 1960 (resb60cat)	1	0.012	*0.004*	2.70	*0.0070*	1.1350
Type of Residence (res3cat)	1	-0.002	*0.004*	-0.55	*<0.5832*	1.1372
Time in Current Employment (cjt)	1	0.002	*0.007*	0.29	*0.7714*	3.0955
Total Hours Worked Prior Week (hrwk)	1	-0.019	*0.006*	-3.41	*0.0006*	2.8840
Marital Status (marr3cat)	1	-0.0004	*0.004*	-0.09	*0.9243*	1.8221
Race-Ethnicity/Hispanic Grouping (race4cat)	1	0.027	*0.003*	7.96	*<0.0001*	1.2297

Table 54
Statistical Significance of Interactions Between Independent Variables using the Best-Fit Logistic Regression Lead Model (1999-2004)

Independent Variables	Age (age4cat)	Charleson Co-Morbidity Scale (CCMS3cat)	Health Insurance (hi2cat)	Protein Intake/AMDR (prot3cat)	Current Pregnancy (pregnant)	U.S. Citizenship (usczn2cat)	Alcohol Consumption (retohuse)	Serum Cotinine (cot3cat)	Age of Residence 1960 (resb60cat)	Type of Residence (res3cat)	Time in Current Employment (cjt)	Total Hours Worked Prior Week (hrwk)	Marital Status (marr3cat)	Race-Ethnicity Hispanic Grouping (race4cat)
Age (age4cat)														
Charleson Co-Morbidity Scale (CCMS3cat)	*op*													
Health Insurance (hi2cat)	*op*	*op*												
Protein Intake/AMDR (prot3cat)	*<0.001*	*<0.01*	*op*											
Current Pregnancy (pregnant)	*op*	*op*	*op*	*ns*										
U.S. Citizenship (usczn2cat)	*<0.001*	*op*	*ns*	*ns*	*ns*									
Alcohol Consumption (retohuse)	*op*	*op*	*op*	*<0.001*	*op*	*<0.05*								
Serum Cotinine (cot3cat)	*<0.001*	*op*	*ns*	*ns*	*ns*	*<0.01*	*<0.001*							
Age of Residence 1960 (resb60cat)	*<0.001*	*<0.001*	*ns*	*<0.001*	*ns*	*ns*	*<0.001*	*<0.001*						
Type of Residence (res3cat)	*<0.001*	*op*	*op*	*<0.01*	*<0.001*	*<0.05*	*ns*	*<0.01*	*op*					
Time in Current Employment (cjt)	*<0.001*	*<0.01*	*op*	*<0.01*	*ns*	*<0.05*	*<0.001*	*<0.001*	*<0.02*	*<0.01*				
Total Hours Worked Prior Week (hrwk)	*<0.001*	*<0.02*	*<0.01*	*<0.001*	*<0.01*	*ns*	*<0.001*	*<0.001*	*ns*	*<0.05*	*op*			
Marital Status (marr3cat)	*op*	*op*	*op*	*<0.05*	*op*	*ns*	*<0.001*	*op*	*<0.001*	*<0.001*	*<0.001*	*<0.001*		
Race-Ethnicity/Hispanic Grouping (race4cat)	*<0.001*	*op*	*op*	*ns*	*op*	*op*	*<0.001*	*ns*	*<0.001*	*<0.001*	*ns*	*<0.001*	*op*	

op = over parameterized unable to calculate
ns = not statistically significant p>0.05

Table 55. Odds Ratios and Confidence Intervals for Best-Fit Logistic Regression Lead Model *with no interactions* (1999-2004)

Variable Names	df	-2LL Wald F	*p* value	Odds Ratios	Confidence Intervals
Susceptibility-Related Attributes					
Age (age4cat)	3	6.12	*0.0014*		
16-19[R]				1.00	*ns*
20-29				0.87	0.47 - 1.63 %
30-39				1.60	0.70 - 3.68 %
40-49				4.31	1.93 - 9.62 %
Health Status					
Charleson Co-Morbidity Scale (CCMS3cat)	2	0.44	*0.6481*		
none[R]				1.00	*ns*
one co-morbidity				0.70	0.28 - 1.72 %
more than one co-morbidity				1.48	0.19 - 11.36 %
Health Insurance (hi2cat)	3	4.18	*0.0109*		
private[R]				1.00	*ns*
public				2.68	1.36 - 5.27 %
none				1.87	1.10 - 3.18 %
missing				1.81	0.25 - 13.33 %
Nutritional Status					
Protein Intake/AMDR (prot3cat)	1	1.92	*0.1727*		
recommended or more[R]				1.00	*ns*
less than recommended				1.64	0.80 - 3.37 %
Reproductive Status					
Current Pregnancy (pregnant)	2	4.96	*0.0114*		
pregnant				0.31	0.14 - 0.65 %
not pregnant[R]				1.00	*ns*
missing				1.23	0.45 - 3.36 %
Exposure-Related Attributes					
Acculturation					
U.S. Citizenship (usczn2cat)	1	29.11	*0.0000*		
U.S. citizen[R]				1.00	*ns*
non-U.S. citizen				7.64	3.57 - 16.32 %
Alcohol Consumption					
Alcohol Consumption (retohuse)	3	3.59	*0.0209*		
never, seldom drinker[R] *including 16-19 y/o*				1.00	*ns*
drinker				1.10	0.63 - 1.94 %
heavy drinker				2.83	1.42 - 5.65 %
missing				1.17	0.38 - 3.55 %
Tobacco Use					
Serum Cotinine (cot3cat)	2	5.16	*0.0097*		
< 1.0 ng/ml[R]				1.00	*ns*
1.0 - 10.0 ng/ml				0.99	0.47 - 2.09 %
> 10.0 ng/ml				2.42	1.39 - 4.21 %
Residence					
Type of Residence (res3cat)	2	1.62	*0.2089*		
attached or detached house[R]				1.00	*ns*
mobile home or trailer				1.72	0.80 - 3.69 %
all other types *including missing/unknown*				0.79	0.47 - 1.34 %
Age of Residence 1960 (resb60cat)	2	6.26	*0.0041*		
1960 or newer[R]				1.00	*ns*
older than 1960				1.92	1.27 - 2.88 %
missing/unknown				1.95	0.96 - 3.98 %
Occupation					
Time in Current Employment (cjt)	2	0.97	*0.3877*		
not working[R]				1.00	*ns*
less than five years				0.96	0.28 - 3.26 %
five or more years				1.49	0.40 - 5.49 %

[R] = referent group

ns = not significant

Table 55. Odds Ratios and Confidence Intervals for Best-Fit Logistic Regression Lead Model *with no interactions* (1999-2004)

Variable Names	df	-2LL Wald F	*p* value	Odds Ratios	Confidence Intervals
Total Hours Worked Prior Week (hrwk)	2	0.20	*0.8160*		
not employed[R]				1.00	*ns*
less than 35 hours				0.84	0.30 - 2.42 %
35+ hours				0.73	0.23 - 2.31 %
Socioeconomic Factors					
Marital Status					
Marital Status (marr3cat)	3	2.29	*0.0917*		
married or living with partner				1.83	0.93 - 3.62 %
widowed, divorced or separated				1.70	0.87 - 3.33 %
never married[R]				1.00	*ns*
missing				3.52	1.26 - 9.86 %
Race-Ethnicity					
Race-Ethnicity/Hispanic Grouping (race4cat)	3	3.36	*0.0269*		
Non-Hispanic White[R]				1.00	*ns*
Non-Hispanic Black				2.23	1.24 - 4.02 %
Hispanic				0.87	0.49 - 1.52 %
Asian, Native American, Pacific Islander & Multi-Racial				0.99	0.43 - 2.29 %

[R] = referent group

ns = not significant

Table 56
Bivariate Analyses of Independent Variables on Methylmercury Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Susceptibility-Related Attributes						
Age (age4cat)						
16-19^{R} $n_{unweighted}$ = 1,085 $n_{weighted}$ = 18,510,468.72	810.00 (42.39%)%) 14,455,029.37 (20.45%)		275.00 (21.79%) 4,055,439.35 (6.35%)			
20-29 $n_{unweighted}$ = 884 $n_{weighted}$ = 45,347,514.91	489.00 (25.59%) 22,668,003.72 (32.07%)		395.00 (31.30%) 22,679,511.19 (35.54%)		147.60 *<0.0001*	7.11 *0.0005*
30-39 $n_{unweighted}$ =702 $n_{weighted}$ = 36,357,836.50	355.00 (18.58%) 17,129,874.37 (24.23%)		347.00 (27.50%) 19,227,962.13 (30.13%)			
40-49 $n_{unweighted}$ =502 $n_{weighted}$ = 34,286,213.30	257.00 (13.45%) 16,432,386.61 (23.25%)		245.00 (19.41%) 17,853,826.69 (27.98%)			
Health Status						
Perceived Health Status (huq2cat)						
excellent, very good, good^{R}	1,680.00 (87.96%) 63,450,323.11 (89.80%)		1,160.00 (91.92%) 60,554,921.99 (94.89%)		12.71 *0.0004*	9.87 *0.0030*
fair, poor	230.00 (12.04%) 7,204,062.21 (10.20%)		102.00 (8.08%) 3,261,817.38 (5.11%)			
Charleson Co-Morbidity Scale (CCMS3cat)						
none^{R}	1,686.00 (88.23%) 60,399,874.70 (85.45%)		1,128.00 (89.38%) 57,857,146.73 (90.66%)			
1 co-morbidity	191.00 (9.99%) 8,506,466.25 (12.03%)		112.00 (8.87%) 4,640,267.06 (7.27%)		1.12 *0.572*	1.66 *0.202*
>1 co-morbidity	34.00 (1.78%) 1,778,953.12 (2.52%)		* (0.00%) 1,319,325.57 (2.07%)			
Iron Deficiency (FeD2cat)						
within normal limits^{R}	1,608.00 (84.14%) 63,789,074.49 (90.24%)		1,116.00 (88.43%) 59,047,684.14 (92.53%)		11.49 *0.0007*	1.04 *0.314*
iron deficient $n_{unweighted}$ = 449 $n_{weighted}$ = 11,665,274.81	303.00 (15.86%) 6,896,219.58 (9.76%)		146.00 (11.57%) 4,769,055.23 (7.47%)			
Treatment for Iron Deficiency past 3 mo (FeTx2cat)						
yes	106.00 (5.55%) 2,391,018.45 (3.38%)		65.00 (5.15%) 2,755,277.52 (4.32%)		0.23 *0.632*	0.21 *0.644*
no^{R}	1,805.00 (94.45%) 68,294,275.61 (96.62%)		1,196.00 (94.85%) 61,047,882.77 (95.68%)			

Table 56
Bivariate Analyses of Independent Variables on Methylmercury Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Iron Deficiency and Treatment (FeDTx)						
normal/no treatment[R]	1,534.00 (80.27%) 62,145,752.62 (87.92%)		1,074.00 (85.17%) 57,296,946.06 (89.80%)			
normal w/treatment	74.00 (3.87%) 1,643,321.87 (2.32%)		41.00 (3.25%) 1,737,159.00 (2.72%)		15.70 *0.001*	0.94 *0.431*
deficient w/treatment	32.00 (1.67%) 747,696.58 (1.06%)		* (0.00%) 1,018,118.52 (1.60%)			
deficient/no treatment	271.00 (14.18%) 6,148,523.00 (8.70%)		122.00 (9.67%) 3,750,936.71 (5.88%)			
Health Insurance (hi2cat)						
private[R]	1,141.00 (59.71%) 49,573,386.95 (70.13%)		901.00 (71.39%) 50,559,391.52 (79.23%)			
public	320.00 (16.75%) 6,926,919.83 (9.80%)		119.00 (9.43%) 2,864,500.25 (4.49%)		54.11 *<0.0001*	4.89 *0.005*
none	408.00 (21.35%) 12,652,508.42 (17.90%)		211.00 (16.72%) 9,110,295.94 (14.28%)			
missing	42.00 (2.20%) 1,532,478.86 (2.17%)		31.00 (2.46%) 1,282,551.66 (2.01%)			
Regular Source of Healthcare (hp2cat)						
yes[R]	1,593.00 (83.36%) 61,192,250.32 (86.57%)		1,080.00 (85.58%) 54,266,032.01 (85.03%)		2.82 *0.093*	0.08 *0.774*
no	318.00 (16.64%) 9,493,043.75 (13.43%)		182.00 (14.42%) 955,707.36 (14.97%)			
Source of Healthcare (hcsre)						
healthcare provider[R]	1,042.00 (54.53%) 44,913,152.13 (63.54%)		765.00 (60.62%) 40,248,687.86 (63.07%)			
clinic	442.00 (23.13%) 13,606,076.26 (19.25%)		234.00 (18.54%) 10,162,020.62 (15.92%)		22.05 *<0.0001*	0.446 *0.721*
ER or none	407.00 (21.30%) 11,199,956.05 (15.84%)		235.00 (18.62%) 11,762,700.70 (18.43%)			
missing	20.00 (1.05%) 966,109.62 (1.37%)		28.00 (2.22%) 1,643,330.19 (2.58%)			

Table 56
Bivariate Analyses of Independent Variables on Methylmercury Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Nutritional Status						
Food Security (food2cat)						
food secure^{R}	1,523.00 (79.70%) 59,147,668.27 (83.68%)		1,049.00 (83.12%) 54,896,244.39 (86.02%)			
food insecure	306.00 (16.01%) 8,649,000.70 (12.24%)		153.00 (12.12%) 5,585,521.34 (8.75%)		9.41 *0.009*	1.80 *0.177*
missing	82.00 (4.29%) 2,888,625.09 (4.09%)		60.00 (4.75%) 3,334,973.63 (5.23%)			
Body Mass Index (bmi30cat)						
<30.0^{R} underweight normal overweight	1,392.00 (72.84%) 53,097,503.59 (75.12%)		965.00 (76.47%) 49,746,393.33 (77.95%)			
30.0+ obese	486.00 (25.43%) 16,312,928.21 (23.08%)		291.00 (23.06%) 13,903,529.59 (21.79%)		12.78 *0.002*	2.74 *0.075*
missing	33.00 (1.73%) 1,274,862.27 (1.80%)		6.00 (0.48%) 166,816.45 (0.26%)			
Fat Intake/AMDR (fat3cat)						
recommended or less^{R}	1,266.00 (66.28%) 45,640,465.88 (64.60%)		782.00 (62.11%) 41,039,249.92 (64.41%)		5.77 *0.016*	0.002 *0.965*
more than recommended	644.00 (33.72%) 25.015.694.25 (35.40%)		477.00 (37.89%) 22,676,951.75 (35.59%)			
Protein Intake/AMDR (prot3cat)						
recommended or more^{R}	1,602.00 (83.83%) 61,008,629.70 (86.31%)		1,110.00 (87.96%) 57,755,135.57 (90.50%)		10.41 *0.0012*	2.62 *0.113*
less than recommended	309.00 (16.17%) 9,676,664.37 (13.69%)		152.00 (12.04%) 6,061,603.79 (9.50%)			
Iron Intake/RDA (iron2cat)						
recommended or more^{R}	1,469.00 (76.87%) 53,617,171.06 (75.85%)		1,045.00 (82.81%) 53,825,146.92 (84.34%)		16.27 *<0.0001*	5.35 *0.025*
less than recommended	442.00 (23.13%) 17,068,123.00 (24.15%)		217.00 (17.19%) 9,991,592.45 (15.66%)			
Calcium Intake/RDA (calc2cat)						
recommended or more^{R}	393.00 (20.57%) 14,092,640.99 (19.94%)		247.00 (19.57%) 11,983,668.21 (18.78%)		0.46 *0.495*	0.09 *0.763*
less than recommended	1,518.00 (79.43%) 56,592,653.07 (80.06%)		1,015.00 (80.43%) 51,833,071.16 (81.22%)			

Table 56
Bivariate Analyses of Independent Variables on Methylmercury Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Selenium Intake/RDA (sele2cat)						
recommended or more^{R}	1,470.00 (76.92%) 55,410,442.98 (78.39%)		1,087.00 (86.13%) 57,234,948.83 (89.69%)		41.21 *<0.0001*	15.05 *0.0003*
less than recommended	441.00 (23.08%) 15,274,851.09 (21.61%)		175.00 (13.87%) 6,581,790.53 (10.31%)			
Reproductive Status						
Current Pregnancy (pregnant)						
pregnant	262.00 (13.71%) 2,877,024.96 (4.07%)		129.00 (10.22%) 1,965,164.13 (3.08%)			
not pregnant^{R}	1,529.00 (80.01%) 64,879,866.53 (91.79%)		1,112.00 (88.11%) 61,496,652.40 (96.36%)		49.94 *<0.0001*	7.97 *0.001*
missing	120.00 (6.28%) 2,928,402.57 (4.14%)		21.00 (1.66%) 354,922.84 (0.56%)			
Trimester of Pregnancy (tripcorr)						
not pregnant^{R}	1,649.00 (86.29%) 67,808,269.11 (95.93%)		1,133.00 (89.78%) 61851575.24 (96.92%)			
1st trimester	91.00 (4.76%) 1,189,057.76 (1.68%)		58.00 (4.60%) 802508.35 (1.26%)		15.25 *0.0016*	0.64 *0.594*
2nd trimester	100.00 (5.23%) 999,781.18 (1.41%)		32.00 (2.54%) 523,714.35 (0.82%)			
3rd trimester	71.00 (3.72%) 688,186.02 (0.97%)		39.00 (3.09%) 638,941.42 (1.00%)			
Ever Pregnant (tprg2cat)						
never pregnant^{R}	981.00 (51.33%) 31,801,576.35 (44.99%)		554.00 (43.90%) 27,763,520.63 (43.51%)		16.83 *<0.0001*	0.09 *0.769*
one or more pregnancies	930.00 (48.67%) 38,883,717.72 (55.01%)		708.00 (56.10%) 36,053,218.73 (56.49%)			
Live Births (live)						
no live births^{R}	1,153.00 (60.33%) 35,540,111.79 (50.28%)		667.00 (52.85%) 31,880,126.42 (49.96%)		17.39 *<0.0001*	0.004 *0.947*
one or more live births	758.00 (39.67%) 35,145,182.28 (49.72%)		595.00 (47.15%) 31,936,612.94 (50.04%)			
Ever Breastfed (brstfda)						
never breastfed^{R}	1,444.00 (75.56%) 49,600,141.20 (70.17%)		879.00 (69.65%) 42,354,181.09 (66.37%)		13.54 *0.0002*	1.13 *0.293*
breastfed more than one month or currently	467.00 (24.44%) 21,085,152.86 (29.83%)		383.00 (30.35%) 21,462,558.27 (33.63%)			

Table 56
Bivariate Analyses of Independent Variables on Methylmercury Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Exposure-Related Attributes						
Acculturation						
Birthplace (born2cat)						
U.S.[R]	1,627.00 (85.14%) 64,008,759.19 (90.55%)		1,046.00 (82.88%) 56,294,937.62 (88.21%)		2.91 *0.88*	0.94 *0.337*
outside U.S.	284.00 (14.86%) 6,676,534.88 (9.45%)		216.00 (17.12%) 7,521,801.75 (11.79%)			
Years in U.S. (yrus5)						
born in U.S.[R]	1627.00 (85.36%) 64,008,759.19 (90.70%)		1,046.00 (82.95%) 56,294,937.62 (88.29%)		12.39 *0.002*	2.74 *0.075*
five or more years	184.00 (9.65%) 4,664,393.86 (6.61%)		168.00 (13.32%) 6,409,125.35 (10.05%)			
less than five years	95.00 (4.98%) 1,896,206.83 (2.69%)		47.00 (3.73%) 1,059,760.09 (1.66%)			
Language Spoken at Home (lang2cat)						
English[R]	1,706.00 (89.27%) 66,529,351.01 (94.12%)		1,138.00 (90.32%) 60,231,843.35 (94.72%)		0.89 0.344	0.21 *0.651*
Other	205.00 (10.73%) 4,155,943.05 (5.88%)		122.00 (9.68%) 3,357,828.66 (5.28%)			
U.S. Citizenship (usczn2cat)						
U.S. citizen[R]	1,685.00 (88.22%) 66,431,518.33 (94.01%)		1,129.00 (89.46%) 60,393,753.58 (94.64%)		1.17 *0.279*	0.22 *0.640*
non-U.S. citizen	225.00 (11.78%) 4,231,907.05 (5.99%)		133.00 (10.54%) 3,422,985.79 (5.36%)			
Diet						
Seafood Eaten in Past 30 Days (smpw2cat)						
none[R]	608.00 (31.82%) 20,242,379.86 (28.64%)		78.00 (6.18%) 2,628,460.93 (4.12%)		294.76 *<0.0001*	67.08 *0.0000*
any	1,303.00 (68.18%) 50,442,914.21 (71.36%)		1,184.00 (93.82%) 61,188,278.44 (95.88%)			
Fish Eaten in Past 30 Days (fish2cat)						
none[R]	877.00 (45.89%) 30,759,747.06 (43.52%)		163.00 (12.92%) 6,049,992.61 (9.48%)		375.12 *<0.0001*	118.37 *0.0000*
any	1,034.00 (54.11%) 39,925,547.00 (56.48%)		1,099.00 (87.08%) 57,766,746.76 (90.52%)			

Table 56
Bivariate Analyses of Independent Variables on Methylmercury Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Shellfish Eaten in Past 30 Days (shell2cat)						
none[R]	1,113.00 (58.24%) 39,932,083.11 (56.49%)		444.00 (35.18%) 23,086,556.07 (36.18%)		161.72 *<0.0001*	17.18 *0.0002*
any	798.00 (41.76%) 30,753,210.95 (43.51%)		818.00 (64.82%) 40,730,183.30 (63.82%)			
Tap Water Consumed Prior 24h (tap2kct)						
none[R]	714.00 (37.36%) 23,745,482.27 (33.59%)		415.00 (32.88%) 16,759,345.97 (26.26%)			
< 2,000 ml	868.00 (45.42%) 33,285,324.77 (47.09%)		670.00 (53.09%) 37,760,160.66 (59.17%)		18.85 *0.0003*	5.15 *0.0039*
2,000+ ml	188.00 (9.84%) 8,452,430.26 (11.96%)		107.00 (8.48%) 7,077,122.24 (11.09%)			
missing	141.00 (7.38%) 5,202,056.77 (7.36%)		70.00 (5.55%) 2,220,110.49 (3.48%)			
Alcohol Consumption						
Alcohol Consumption (retohuse)						
never, seldom drinker[R] *including 16-19 y/o*	1,205.00 (63.06%) 32,093,577.92 (45.40%)		538.00 (42.63%) 20,126,937.45 (31.54%)			
drinker	386.00 (20.20%) 20.660.784.95 (29.23%)		344.00 (27.26%) 20,009,294.62 (31.35%)		135.79 <0.0001	3.48 *0.024*
heavy drinker	255.00 (13.34%) 15,637,342.25 (22.12%)		300.00 (23.77%) 20,128,037.19 (31.54%)			
missing	65.00 (3.40%) 2,293,588.95 (3.24%)		80.00 (6.34%) 3,552,470.10 (5.57%)			
Tobacco Use						
Serum Cotinine (cot3cat)						
< 1.0 ng/ml[R]	1,407.00 (74.05%) 49,609,568.34 (70.70%)		961.00 (76.39%) 49,261,905.23 (77.33%)			
1.0 - 10.0 ng/ml	135.00 (7.11%) 3,406,027.43 (4.85%)		55.00 (4.37%) 1,844,274.19 (2.90%)		10.01 *0.007*	2.55 *0.089*
> 10.0 ng/ml	358.00 (18.84%) 17,156,220.02 (24.45%)		242.00 (19.24%) 12,594,121.21 (19.77%)			

Table 56
Bivariate Analyses of Independent Variables on Methylmercury Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
ETS (ETS)						
no ETS^{R}	1,415.00 (74.05%) 51,322,375.31 (72.61%)		1,002.00 (79.40%) 50,474,996.27 (79.09%)			
ETS at home or work	442.00 (23.13%) 16,219,182.51 (22.95%)		208.00 (16.48%) 10,487,687.09 (16.43%)		23.07 *<0.0001*	1.84 *0.170*
ETS at home and work	54.00 (2.83%) 3,143,736.25 (4.45%)		52.00 (4.12%) 2,854,056.01 (4.47%)			
Residence						
Tap Water Source (h2os2cat)						
public^{R}	1665.00 (87.13%) 59,607,539.62 (84.33%)		1161.00 (92.00%) 57,128,368.55 (89.52%)			
private	199.00 (10.41%) 9,648,683.80 (13.65%)		67.00 (5.31%) 4,842,851.22 (7.59%)		25.81 *<0.0001*	2.71 *0.078*
missing	47.00 (2.46%) 1,429,070.65 (2.02%)		34.00 (2.69%) 1,845,519.59 (2.89%)			
Residential Tap Water Treatment (h2ox2cat)						
yes	490.00 (25.64%) 21,607,404.37 (30.57%)		373.00 (29.56%) 23,700,830.29 (37.14%)			
no^{R}	1,378.00 (72.11%) 47,657,844.04 (67.42%)		861.00 (68.23%) 38,887,493.32 (60.94%)		5.91 *0.053*	1.19 *0.315*
missing	43.00 (2.25%) 1,420,045.65 (2.01%)		28.00 (2.22%) 1,228,415.75 (1.92%)			
Type of Residence (res3cat)						
attached or detached house^{R}	1,222.00 (63.95%) 45,821,302.96 (64.82%)		850.00 (67.35%) 43,484,667.60 (68.14%)			
mobile home or trailer	147.00 (7.69%) 5,786,760.79 (8.19%)		55.00 (4.36%) 2,615,017.01 (4.10%)		14.62 *0.0007*	3.15 *0.053*
all other types *including missing/unknown*	542.00 (28.36%) 19,077,230.32 (26.99%)		357.00 (28.29%) 17,717,054.75 (27.76%)			
Age of Residence (resb60cat)						
1960 or newer^{R}	938.00 (49.08%) 40,533,763.38 (57.34%)		657.00 (52.06%) 37,510,760.64 (58.78%)			
older than 1960	472.00 (24.70%) 16,533,334.37 (23.39%)		294.00 (23.30%) 15,558,865.73 (24.38%)		2.69 *0.260*	0.24 *0.786*
missing/unknown	501.00 (26.22%) 13,618,196.32 (19.27%)		311.00 (24.64%) 10,747,112.99 (16.84%)			

Table 56
Bivariate Analyses of Independent Variables on Methylmercury Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Age of Residence (resb78cat)						
1978 or newer[R]	613.00 (32.08%) 27,813,984.59 (39.35%)		474.00 (37.56%) 27,574,064.27 (43.21%)			
older than 1978	797.00 (41.71%) 29,253,113.15 (41.39%)		477.00 (37.80%) 25,495,562.11 (39.95%)		10.29 *0.006*	0.43 *0.650*
missing/unknown	501.00 (26.22%) 13,618,196.32 (19.27%)		311.00 (24.64%) 10,747,112.99 (16.84%)			
Resident Status (resd3cat)						
own[R]	1,022.00 (53.48%) 40,079,923.43 (56.70%)		705.00 (55.86%) 37,170,383.70 (58.25%)			
rent	767.00 (40.14%) 26,463,587.74 (37.44%)		511.00 (40.49%) 24,700,307.83 (38.71%)		11.59 *0.003*	1.34 *0.273*
other *including missing*	122.00 (6.38%) 4,141,782.90 (5.86%)		46.00 (3.65%) 1,946,047.83 (3.05%)			
Years at Current Residence (re5yrcat)						
more than five years[R]	680.00 (35.58%) 25,459,430.14 (36.02%)		433.00 (34.31%) 20,434,888.55 (32.02%)			
five years or less	1,207.00 (63.16%) 44,382,216.50 (62.79%)		800.00 (63.39%) 42,073,396.44 (65.93%)		5.29 *0.071*	0.69 *0.504*
missing	24.00 (1.26%) 843,647.42 (1.19%)		29.00 (2.30%) 1,308,454.38 (2.05%)			
Household Size (hsize)						
four persons or less[R]	1,232.00 (64.47%) 53,365,258.09 (75.50%)		950.00 (75.28%) 53,088,770.29 (83.19%)			
more than four persons	679.00 (35.53%) 17,320,035.97 (24.50%)		312.00 (24.72%) 10,727,969.07 (16.81%)		41.34 *<0.0001*	5.09 *0.029*
Rooms in Residence (rm3cat)						
7+ rooms[R]	649.00 (33.96%) 26,314,597.91 (37.23%)		499.00 (39.54%) 26,301,914.90 (41.21%)			
4-6 rooms	1,075.00 (56.25%) 38,280,251.55 (54.16%)		616.00 (48.81%) 30,819,881.04 (48.29%)		17.32 *0.0006*	0.38 *0.763*
1-3 rooms	145.00 (7.59%) 4,887,472.26 (6.91%)		118.00 (9.35%) 5,287,700.85 (8.29%)			
missing	42.00 (2.20%) 1,202,972.35 (1.70%)		29.00 (2.30%) 1,407,242.57 (2.21%)			

Table 56
Bivariate Analyses of Independent Variables on Methylmercury Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Occupation						
Current Occupation (cocc2cat)						
not working^{R}	876.00 (45.84%) 25,214,830.94 (35.67%)		448.00 (35.50%) 16,958,126.63 (26.57%)			
management, professional & sales	666.00 (34.85%) 32,727,760.81 (46.30%)		577.00 (45.72%) 35,031,130.92 (54.89%)		42.51 *<0.0001*	1.68 *0.198*
services & goods	369.00 (19.31%) 12,742,702.31 (18.03%)		237.00 (18.78%) 11,827,481.81 (18.53%)			
Time in Current Employment (cjt)						
not working^{R}	876.00 (45.84%) 25,214,830.94 (35.67%)		448.00 (35.50%) 16,958,126.63 (26.57%)			
less than five years	857.00 (44.85%) 34,136,542.67 (48.29%)		577.00 (45.72%) 33,105,097.05 (51.88%)		71.67 *<0.0001*	1.96 *0.153*
more than five years	178.00 (9.31%) 11,333,920.45 (16.03%)		237.00 (18.78%) 13,753,515.68 (21.55%)			
Total Hours Worked Prior Week (hrwk)						
not employed^{R}	910.00 (47.67%) 27,405,434.12 (38.85%)		471.00 (37.32%) 18,402,603.91 (28.84%)			
less than 35 hours	432.00 (22.63%) 14,877,373.97 (21.09%)		304.00 (24.09%) 18,490,059.83 (28.97%)		37.43 *<0.0001*	1.56 *0.222*
35+ hours	567.00 (29.70%) 28,257,445.38 (40.06%)		487.00 (38.59%) 26,924,075.63 (42.19%)			
Longest Held Occupation (locc2cat)						
not applicable^{R}	937.00 (49.03%) 34,396,695.60 (48.66%)		625.00 (49.52%) 29,720,660.91 (46.57%)			
management, professional & sales	528.00 (27.63%) 21,722,891.47 (30.73%)		375.00 (29.71%) 19,692,294.68 (30.86%)		3.46 *0.177*	0.16 *0.852*
services & goods	446.00 (23.34%) 14,565,706.99 (20.61%)		262.00 (20.76%) 14,403,783.78 (22.57%)			
Time in Longest Employment (ljt)						
not applicable^{R}	937.00 (49.03%) 34,396,695.60 (48.66%)		625.00 (49.52%) 29,720,660.91 (46.57%)			
less than five years	662.00 (34.64%) 21.201.670.86 (29.99%)		335.00 (26.55%) 13,340,597.99 (20.90%)		38.60 *<0.0001*	2.08 *0.136*
five or more years	312.00 (16.33%) 15,086,927.61 (21.34%)		302.00 (23.93%) 20,755,480.47 (32.52%)			

Table 56
Bivariate Analyses of Independent Variables on Methylmercury Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Work History (wkcp)						
never employed[R]	297.00 (15.54%) 5,919,953.87 (8.38%)		111.00 (8.80%) 2,318,856.93 (3.63%)			
currently employed	640.00 (33.49%) 28,476,741.73 (40.29%)		514.00 (40.73%) 27,401,803.98 (42.94%)		44.59 *<0.0001*	2.21 *0.100*
employed in the past but not currently	579.00 (30.30%) 19,294,877.07 (27.30%)		337.00 (26.70%) 14,639,269.71 (22.94%)			
employed now and in the past	395.00 (20.67%) 16,993,721.39 (24.04%)		300.00 (23.77%) 19,456,808.75 (30.49%)			
Socioeconomic Factors						
Education						
Highest Education (educ2)						
high school diploma, GED or higher[R]	1,083.00 (56.67%) 52,397,693.39 (74.13%)		954.00 (75.65%) 54,509,467.95 (85.51%)		119.13 *<0.0001*	6.25 *0.02*
less than high school diploma	828.00 (43.33%) 18,287,600.67 (25.87%)		307.00 (24.35%) 9,240,132.63 (4.49%)			
Employment						
Employment Status (emp3cat)						
employed	1,039.00 (54.43%) 45,610,187.23 (64.54%)		814.00 (64.50%) 46,858,612.73 (73.43%)		31.75 *<0.0001*	2.27 *0.139*
not employed[R]	870.00 (45.57%) 25,063,887.32 (35.46%)		448.00 (35.50%) 16,958,126.63 (26.57%)			
Reason for Unemployment (unem2cat)						
working[R]	1,039.00 (54.37%) 45,610,187.23 (64.53%)		814.00 (64.50%) 46,858,612.73 (73.43%)			
voluntary unemployment	600.00 (31.40%) 16,867,871.13 (23.86%)		324.00 (25.67%) 11,397,150.54 (17.86%)		36.18 *<0.0001*	0.77 *0.516*
involuntary unemployment	196.00 (10.26%) 5,956,503.95 (8.43%)		99.00 (7.84%) 4,306,610.06 (6.75%)			
missing	76.00 (3.98%) 2,250,731.76 (3.18%)		25.00 (1.98%) 1,254,366.03 (1.97%)			
Income						
U.S. Poverty Threshold (pov2cat)						
more than 1.00[R]	1,287.00 (67.35%) 54,471,372.99 (77.06%)		940.00 (74.48%) 49,482,250.20 (77.54%)		26.16 *<0.0001*	1.28 *0.287*
1.00 or less	499.00 (26.11%) 13,125,723.04 (18.57%)		231.00 (18.30%) 9,461,474.43 (14.83%)			
missing	125.00 (6.54%) 3,088,198.03 (4.37%)		91.00 (7.21%) 4.873.014.74 (7.64%)			

Table 56
Bivariate Analyses of Independent Variables on Methylmercury Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Marital Status						
Marital Status (marr3cat)						
married or living with partner	683.00 (35.74%) 33,354,082.47 (47.19%)		515.00 (40.81%) 28,446,565.78 (44.58%)			
widowed, divorced or separated	140.00 (7.33%) 6,588,677.95 (9.32%)		121.00 (9.59%) 7,765,274.43 (12.17%)		24.17 *<0.0001*	0.68 *0.569*
never married^{R}	1,050.00 (54.95%) 28,651,239.71 (40.53%)		587.00 (46.51%) 24,841,711.78 (38.93%)			
missing	38.00 (1.99%) 2,091,293.94 (2.96%)		39.00 (3.09%) 2,763,187.37 (4.33%)			
Race-Ethnicity						
Race-Ethnicity (race5cat)						
Non-Hispanic White^{R} $n_{unweighted}$ = 1493 $n_{weighted}$ = 97,887,544.16	881.00 (46.10%) 51,861,986.93 (73.37%)		612.00 (48.49%) 46,025,557.23 (72.12%)			
Non-Hispanic Black $n_{unweighted}$ = 623 $n_{weighted}$ = 12,747,178.37	353.00 (18.47%) 6,195,923.44 (8.77%)		270.00 (21.39%) 6,551,254.92 (10.27%)			
Mexican American $n_{unweighted}$ = 745 $n_{weighted}$ = 8,670,575.80	508.00 (26.58%) 5,459,501.32 (7.72%)		237.00 (18.78%) 3,211,074.49 (5.03%)		28.86 *<0.0001*	2.45 *0.059*
Other Hispanic $n_{unweighted}$ = 178 $n_{weighted}$ = 7,525,992.22	98.00 (5.13%) 3,709,893.41 (5.25%)		80.00 (96.34%) 3,816,098.81 (5.98%)			
Asian, Native American, Pacific Islander & Multi-Racial $n_{unweighted}$ = 134 $n_{weighted}$ = 7,670,742.88	71.00 (3.72%) 3,457,988.97 (4.89%)		63.00 (4.99%) 4,212,753.91 (6.60%)			
Race-Ethnicity/Hispanic Grouping (race4cat)						
Non-Hispanic White^{R} $n_{unweighted}$ = 1493 $n_{weighted}$ = 97,887,544.16	881.00 (46.10%) 51,861,986.93 (73.37%)		612.00 (48.49%) 46,025,557.23 (72.12%)			
Non-Hispanic Black $n_{unweighted}$ = 623 $n_{weighted}$ = 12,747,178.37	353.00 (18.47%) 6,195,923.44 (8.77%)		270.00 (21.39%) 6,551,254.92 (10.27%)		18.52 *0.0003*	0.55 *0.650*
Hispanic $n_{unweighted}$ = 923 $n_{weighted}$ = 16,196,568.02	606.00 (31.71%) 9,169,394.73 (12.97%)		317.00 (25.12%) 7,027,173.30 (11.01%)			
Asian, Native American, Pacific Islander & Multi-Racial $n_{unweighted}$ = 134 $n_{weighted}$ = 7,670,742.88	71.00 (3.72%) 3,457,988.97 (4.89%)		63.00 (4.99%) 4,212,753.91 (6.60%)			

Table 57
Summary of Chi-Square and *p* Values of Weighted Independent Variables on Methylmercury (1999-2004)

Variables *p < 0.20*	*p* value	χ^2 *weighted*	Variables *p > 0.20*	*p* value	χ^2 *weighted*
Fish in Past 30 Days (fish2cat)	*0.0000*	118.37	Charleson Co-Morbidity Scale (CCMS3cat)	*0.202*	1.66
Seafood in Past 30 Days [1] (smpw2cat)	*0.0000*	67.08	Total Hours Worked Prior Week (hrwk)	*0.222*	1.56
Shellfish in Past 30 Days (shell2cat)	*0.0002*	17.18	Resident Status (resd3cat)	*0.273*	1.34
Selenium Intake/RDA (sele2cat)	*0.0003*	15.05	U.S. Poverty Threshold (pov2cat)	*0.287*	1.28
Age (age4cat)	*0.0005*	7.11	Ever Breastfed (brstfda)	*0.293*	1.13
Current Pregnancy (pregnant)	*0.001*	7.97	Iron Deficiency (FeD2cat)	*0.314*	1.04
Perceived Health Status (huq2cat)	*0.003*	9.87	Residential Tap Water Treatment (h2ox2cat)	*0.315*	1.19
Tap Water Consumed 24h (tap2kct)	*0.0039*	5.15	Birthplace (born2cat)	*0.337*	0.94
Health Insurance (hi2cat)	*0.005*	4.89	Iron Deficiency and Treatment (FeDTx)	*0.431*	0.94
Highest Education (educ2)	*0.016*	6.25	Years at Current Residence (re5yrcat)	*0.504*	0.69
Alcohol Consumption (retohuse)	*0.024*	3.48	Reason for Unemployment (unem2cat)	*0.516*	0.77
Iron Intake/RDA[1] (iron2cat)	*0.025*	5.35	Marital Status (marr3cat)	*0.569*	0.68
Household Size (hsize)	*0.029*	5.09	Trimester of Pregnancy[1] (tripcorr)	*0.594*	0.64
Type of Residence (res3cat)	*0.053*	3.15	U.S. Citizenship (usczn2cat)	*0.64*	0.22
Race-Ethnicity[1] (race5cat)	*0.059*	2.45	Treatment for Iron Deficiency past 3 mo (FeTx2cat)	*0.644*	0.21
Body Mass Index (bmi30cat)	*0.075*	2.74	Race-Ethnicity/Hispanic Grouping (race4cat)	*0.650*	0.55
Years in U.S. (yrus5)	*0.075*	2.74	Age of Residence (resb78cat)	*0.65*	0.43
Tap Water Source[1] (h2os2cat)	*0.078*	2.71	Language Spoken at Home (lang2cat)	*0.651*	0.21
Serum Cotinine (cot3cat)	*0.089*	2.55	Source of Healthcare (hscre)	*0.721*	0.45
Work History[1] (wkcp)	*0.100*	2.21	Rooms in Residence (rm3cat)	*0.763*	0.38
Protein Intake/AMDR (prot3cat)	*0.113*	2.62	Calcium Intake/RDA (calc2cat)	*0.763*	0.09
Time in Longest Employment (ljt)	*0.136*	2.08	Ever Pregnant[1] (tprg2cat)	*0.769*	0.09
Employment Status (emp3cat)	*0.139*	2.27	Regular Source of Healthcare (hp2cat)	*0.774*	0.08
Time in Current Employment[1] (cjt)	*0.153*	1.96	Age of Residence (resb60cat)	*0.786*	0.24
Environmental Tobacco Smoke[1] (ETS)	*0.170*	1.84	Longest Held Occupation (locc2cat)	*0.852*	0.16
Food Security[1] (food2cat)	*0.177*	1.80	Live Births (live)	*0.947*	0.00
Current Occupation[1] (cocc2cat)	*0.198*	1.68	Fat Intake/AMDR (fat3cat)	*0.965*	0.00

[1]variable dropped due to low cell size or too similar to other variables

Table 58
Stepwise Logistic Regression Analyses of Methylmercury
(1999-2004)

Variable Name *p < 0.20*	df	-2LL Wald F	Difference	df	*p* value
Initial Regression	34	858.44			
1 Highest Education (educ2)	33	855.70	2.74	1	*>0.05* *drop*
2 Years in U.S. (yrus5)	31	855.14	0.56	2	*>0.20* *drop*
3 Protein Intake/AMDR (prot3cat)	30	854.69	0.45	1	*>0.20* *drop*
4 Race-Ethnicity/Hispanic Grouping (race4cat)	27	840.81	13.88	3	*<0.01* *keep*
5 Health Insurance (hi2cat)	27	849.95	4.74	3	*>0.10* *drop*
6 Serum Cotinine (cot3cat)	25	845.30	4.65	2	*>0.05* *drop*
7 Alcohol Consumption (retohuse)	22	819.83	25.47	3	*<0.001* *keep*
8 Body Mass Index (bmi30cat)	23	836.15	9.15	2	*<0.02* *keep*
9 Tap Water Consumed 24h (tap2kct)	22	820.64	24.66	3	*<0.001* *keep*
10 Type of Residence (res3cat)	23	823.17	22.13	2	*<0.001* *keep*
11 Household Size (hsize)	24	839.15	6.15	1	*<0.02* *keep*
12 Time in Longest Employment (ljt)	23	813.57	31.73	2	*<0.001* *keep*
13 Perceived Health Status (huq2cat)	24	833.05	12.25	1	*<0.001* *keep*
14 Age (age4cat)	22	819.52	25.78	3	*<0.001* *keep*
15 Current Pregnancy (pregnant)	23	827.90	17.40	2	*<0.001* *keep*
16 Selenium Intake/RDA (sele2cat)	24	827.26	180.04	1	*<0.001* *keep*
17 Shellfish in Past 30 Days (shell2cat)	24	803.69	41.61	1	*<0.001* *keep*
18 Fish in Past 30 Days (fish2cat)	24	483.99	361.31	1	*<0.001* *keep*

Table 59
Best-Fit Logistic Regression Methylmercury Model *with no interactions*
(1999-2004)

Variable Name	df	-2LL Wald F	R^2		*p* value
Best Fit Regression	25	845.30	*0.2339*		
Fish in Past 30 Days (fish2cat)	1	49.57			*0.0000*
Shellfish in Past 30 Days (shell2cat)	1	7.86			*0.0075*
Perceived Health Status (huq2cat)	1	5.64			*0.0219*
Type of Residence (res3cat)	2	3.49			*0.0392*
Age (age4cat)	3	3.03			*0.0393*
Current Pregnancy (pregnant)	2	2.41			*0.1011*
Time in Longest Employment (ljt)	2	2.41			*0.1012*
Selenium Intake/RDA (sele2cat)	1	2.51			*0.1201*
Tap Water Consumed 24h (tap2kct)	3	1.66			*0.1898*
Household Size (hsize)	1	1.65			*0.2063*
Body Mass Index (bmi30cat)	2	1.22			*0.3047*
Alcohol Consumption (retohuse)	3	1.23			*0.3090*
Race-Ethnicity/Hispanic Grouping (race4cat)	3	0.53			*0.6630*

[1] in ascending order by p value

Table 60
Variance Inflation Factor Test for Collinearity Among Independent Variables using the Best-Fit Logistic Regression Methylmercury Model (1999-2004)

	df	sum of squares	mean square	F value	pr>F	
Best Fit Methylmercury Model *with no interactions*	13	475.83	36.602	236.83	*<0.0001*	

Variable Name	df	parameter estimate	std error	t value	pr>t	VIF
Intercept	1	0.276	0.030	9.06	*<0.0001*	0.0000
Age (age4cat)	1	0.049	*0.003*	18.60	*<0.0001*	1.3457
Perceived Health Status (huq2cat)	1	-0.062	*0.009*	-7.15	*<0.0001*	1.0427
Body Mass Index (bmi30cat)	1	-0.022	*0.006*	-3.83	*0.0001*	1.0467
Selenium Intake/RDA (sele2cat)	1	0.005	*0.005*	0.99	*0.3220*	1.2023
Current Pregnancy (pregnant)	1	-0.120	*0.005*	-24.66	*<0.0001*	1.3146
Fish in Past 30 Days (fish2cat)	1	0.104	*0.007*	15.91	*<0.0001*	1.5611
Shellfish in Past 30 Days (shell2cat)	1	0.065	*0.007*	9.75	*<0.0001*	1.4184
Tap Water Consumed 24h (tap2kct)	1	0.004	*0.003*	1.2	*0.2311*	1.1557
Alcohol Consumption (retohuse)	1	0.003	*0.003*	0.83	*0.4059*	1.3577
Type of Residence (res3cat)	1	0.006	*0.003*	2.17	*0.0303*	1.0580
Household Size (hsize)	1	-0.026	*0.006*	-4.55	*<0.0001*	1.1123
Time in Longest Employment (ljt)	1	0.007	*0.003*	1.98	*0.0481*	1.0432
Race-Ethnicity/Hispanic Grouping (race4cat)	1	0.012	*0.0029*	4.16	*<0.0001*	1.1297

Table 61
Statistical Significance of Interactions Between Independent Variables using the Best-Fit Logistic Regression Methylmercury Model (1999-2004)

Independent Variables	Age (age4cat)	Perceived Health Status (huq2cat)	Body Mass Index (bmi30cat)	Selenium Intake/RDA (sele2cat)	Current Pregnancy (pregnant)	Fish in Past 30 Days (fish2cat)	Shellfish in Past 30 Days (shell2cat)	Tap Water Consumed 24h (tap2kct)	Alcohol Consumption (retohuse)	Type of Residence (res3cat)	Household Size (hsize)	Time in Longest Employment (ljt)	Race-Ethnicity Hispanic Grouping (race4cat)
Age (age4cat)													
Perceived Health Status (huq2cat)	*<0.001*												
Body Mass Index (bmi30cat)	*op*	*<0.05*											
Selenium Intake/RDA (sele2cat)	*ns*	*ns*	*ns*										
Current Pregnancy (pregnant)	*op*	*ns*	*op*	*<0.01*									
Fish in Past 30 Days (fish2cat)	*<0.001*	*ns*	*<0.001*	*<0.001*	*ns*								
Shellfish in Past 30 Days (shell2cat)	*<0.001*	*ns*	*op*	*<0.01*	*<0.05*	*ns*							
Tap Water Consumed 24h (tap2kct)	*<0.05*	*ns*	*op*	*<0.001*	*<0.05*	*<0.001*	*<0.01*						
Alcohol Consumption (retohuse)	*op*	*ns*	*op*	*ns*	*op*	*<0.01*	*<0.001*	*<0.001*					
Type of Residence (res3cat)	*ns*	*ns*	*op*	*<0.01*	*ns*	*<0.001*	*ns*	*<0.001*	*op*				
Household Size (hsize)	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*<0.001*	*<0.01*	*<0.01*	*ns*			
Time in Longest Employment (ljt)	*op*	*ns*	*op*	*ns*	*op*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.01*	*<0.001*		
Race-Ethnicity/Hispanic Grouping (race4cat)	*<0.001*	*ns*	*op*	*ns*	*op*	*<0.001*	*<0.001*	*<0.001*	*op*	*<0.001*	*<0.05*	*<0.001*	

op = over parameterized unable to calculate
ns = not statistically significant p>0.05

Table 62
Odds Ratios and Confidence Intervals for Best-Fit Logistic Regression Methylmercury Model
with no interactions (1999-2004)

Variable Names	df	-2LL Wald F	*p* value	Odds Ratios	Confidence Intervals
Susceptibility-Related Attributes					
Age (age4cat)	3	3.03	*0.0393*		
16-19[R]				1.00	*ns*
20-29				2.32	1.30 - 4.14 %
30-39				2.14	1.17 - 3.93 %
40-49				2.11	1.06 - 4.22 %
Health Status					
Perceived Health Status (huq2cat)	1	5.64	*0.0219*		
excellent, very good, good[R]				1.00	*ns*
fair, poor				0.55	0.33 - 0.91 %
Nutritional Status					
Body Mass Index (bmi30cat)	2	1.22	*0.3047*		
<30.0[R] underweight, normal, overweight				1.00	*ns*
30.0+ obese				0.83	0.51 - 1.34 %
missing				0.24	0.03 - 1.97 %
Selenium Intake/RDA (sele2cat)	1	2.51	*0.1201*		
recommended or more[R]				1.00	*ns*
less than recommended				0.60	0.32 - 1.15 %
Reproductive Status					
Current Pregnancy (pregnant)	2	2.41	*0.1011*		
pregnant				0.65	0.37 - 1.11 %
not pregnant[R]				1.00	*ns*
missing				0.24	0.03 - 2.06 %
Exposure-Related Attributes					
Diet					
Fish in Past 30 Days (fish2cat)	1	49.57	*0.0000*		
none[R]				1.00	*ns*
any				6.63	3.86 - 11.38 %
Shellfish in Past 30 Days (shell2cat)	1	7.86	*0.0075*		
none[R]				1.00	*ns*
any				1.73	1.17 - 2.57 %
Tap Water Consumed 24h (tap2kct)	3	1.66	*0.1898*		
none[R]				1.00	*ns*
< 2,000 ml				1.35	0.89 - 2.05 %
2,000+ ml				0.86	0.37 - 1.97 %
missing				0.70	0.34 - 1.43 %
Alcohol Consumption					
Alcohol Consumption (retohuse)	3	1.23	*0.3090*		
never, seldom drinker[R] *including 16-19 y/o*				1.00	*ns*
drinker				0.81	0.47 - 1.39 %
heavy drinker				1.29	0.70 - 2.39 %
missing				1.76	0.77 - 4.02 %
Residence					
Type of Residence (res3cat)	2	3.49	*0.0392*		
attached or detached house[R]				1.00	*ns*
mobile home or trailer				0.44	0.22-0.86 %
all other types *including missing/unknown*				1.00	0.62 - 1.61 %
Household Size (hsize)	1	1.65	*0.2063*		
four persons or less[R]				1.00	*ns*
more than four persons				0.76	0.49 - 1.17 %
Occupation					
Time in Longest Employment (ljt)	2	2.41	*0.1012*		
not applicable[R]				1.00	*ns*
less than five years				0.62	0.38 - 1.03 %
five or more years				1.26	0.78 - 2.03 %

[R] = referent group
ns = not significant

Table 62
Odds Ratios and Confidence Intervals for Best-Fit Logistic Regression Methylmercury Model
with no interactions (1999-2004)

Variable Names	df	-2LL Wald F	*p* value	Odds Ratios	Confidence Intervals
Race-Ethnicity					
Race-Ethnicity/Hispanic Grouping (race4cat)	3	0.53	*0.6630*		
Non-Hispanic White[R]				1.00	*ns*
Non-Hispanic Black				1.42	0.74 - 2.72 %
Hispanic				1.26	0.77 - 2.08 %
Asian, Native American, Pacific Islander & Multi-Racial				1.44	0.41 - 4.97 %

[R] = referent group
ns = not significant

Table 63
Bivariate Analyses of Independent Variables on Sum of PCBs Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Susceptibility-Related Attributes						
Age (age4cat)						
16-19^{R} $n_{unweighted}$ = 1,085 $n_{weighted}$ = 18,510,468.72	730.00 (48.89%) 12,591,232.42 (27.97%)		355.00 (21.13%) 5,919,236.31 (6.61%)			
20-29 $n_{unweighted}$ = 884 $n_{weighted}$ = 45,347,514.91	495.00 (33.15%) 21,467,627.54 (47.70%)		389.00 (23.15%) 23,879,887.37 (26.68%)		576.23 *<0.0001*	26.44 *0.0000*
30-39 $n_{unweighted}$ =702 $n_{weighted}$ = 36,357,836.50	229.00 (15.34%) 9,747,314.99 (21.66%)		473.00 (28.15%) 26,610,521.52 (29.74%)			
40-49 $n_{unweighted}$ =502 $n_{weighted}$ = 34,286,213.30	39.00 (2.61%) 1,203,971.63 (2.67%)		463.00 (27.56%) 33,082,241.67 (36.97%)			
Health Status						
Perceived Health Status (huq2cat)						
excellent, very good, good^{R}	1,351.00 (90.49%) 41,856,362.84 (92.99%)		1,489.00 (88.68%) 82,148,882.26 (91.83%)		2.75 *0.097*	0.59 *0.443*
fair, poor	142.00 (9.51%) 3,153,783.73 (7.01%)		190.00 (11.32%) 7,312,095.87 (8.17%)			
Charleson Co-Morbidity Scale (CCMS3cat)						
none^{R}	1,304.00 (87.34%) 38,384,929.48 (85.28%)		1,510.00 (89.88%) 79,872,091.95 (89.25%)			
one co-morbidity	167.00 (11.19%) 5,453,663.37 (12.12%)		136.00 (8.10%) 7,693,069.95 (8.60%)		9.84 *0.007*	0.47 *0.626*
more than one co-morbidity	* (0.00%) 1,171,553.72 (2.60%)		34.00 (2.02%) 1,926,724.96 (2.15%)			
Iron Deficiency (FeD2cat)						
within normal limits^{R}	1,245.00 (83.39%) 40,808,918.84 (90.67%)		1,479.00 (88.04%) 82,027,839.78 (91.66%)			
iron deficient $n_{unweighted}$ = 449 $n_{weighted}$ = 11,665,274.81	248.00 (16.61%) 4,201,227.73 (9.33%)		201.00 (11.96%) 7,464,047.08 (8.34%)		14.05 *0.0002*	0.43 *0.516*
Treatment for Iron Deficiency past 3 mo (FeTx2cat)						
yes	83.00 (5.56%) 1,244,972.93 (2.77%)		88.00 (5.24%) 3,901,323.04 (4.36%)		0.16 *0.692*	2.89 *0.096*
no^{R}	1,410.00 (94.44%) 43,765,173.64 (97.23%)		1,591.00 (94.76%) 85,576,984.75 (95.64%)			

Table 63
Bivariate Analyses of Independent Variables on Sum of PCBs Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Iron Deficiency and Treatment (FeDTx)						
normal/no treatment^{R}	1,195.00 (80.04%) 40,135,834.13 (89.17%)		1,413.00 (84.16%) 79,306,864.55 (88.63%)			
normal w/treatment	50.00 (3.35%) 673,084.71 (1.50%)		65.00 (3.87%) 2,707,396.16 (3.03%)		14.59 *0.002*	1.49 *0.228*
deficient w/treatment	33.00 (2.21%) 571,888.22 (1.27%)		* (0.00%) 1,193,926.89 (1.33%)			
deficient/no treatment	215.00 (14.40%) 3,629,339.51 (8.06%)		178.00 (10.60%) 6,270,120.20 (7.01%)			
Health Insurance (hi2cat)						
private^{R}	870.00 (58.27%) 30,234,802.03 (67.17%)		1,172.00 (69.76%) 69,897,976.44 (78.11%)			
public	276.00 (18.49%) 3,894,084.20 (8.65%)		163.00 (9.70%) 5,897,335.88 (6.59%)		66.31 *<0.0001*	3.44 *0.025*
none	303.00 (20.29%) 9,622,947.81 (21.38%)		316.00 (18.81%) 12,139,856.55 (13.57%)			
missing	44.00 (2.95%) 1,258,312.52 (2.80%)		29.00 (1.73%) 1,556,717.99 (1.74%)			
Regular Source of Healthcare (hp2cat)						
yes^{R}	1,245.00 (83.39%) 37,055,253.83 (82.33%)		1,428.00 (85.00%) 78,403,028.49 (87.61%)		1.54 *0.214*	1.51 *0.226*
no	248.00 (16.61%) 7,954,892.73 (17.67%)		252.00 (15.00%) 11,088,858.37 (12.39%)			
Source of Healthcare (hcsre)						
healthcare provider^{R}	785.00 (52.58%) 25,696,440.66 (57.09%)		1,022.00 (60.83%) 59,465,399.34 (66.45%)			
clinic	357.00 (23.91%) 7,778,732.74 (17.28%)		319.00 (18.99%) 15,989,364.13 (17.87%)		36.72 *<0.0001*	2.09 *0.114*
ER or none	314.00 (21.03%) 9,179,047.38 (20.39%)		328.00 (19.52%) 13,783,609.38 (15.40%)			
missing	37.00 (2.48%) 2,355,925.79 (5.23%)		11.00 (0.65%) 253,514.02 (0.28%)			

Table 63
Bivariate Analyses of Independent Variables on Sum of PCBs Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Nutritional Status						
Food Security (food2cat)						
food secure[R]	1,155.00 (77.36%) 35,515,569.91 (78.91%)		1,417.00 (84.35%) 78,528,342.75 (87.75%)			
food insecure	261.00 (17.48%) 6,952,393.71 (15.45%)		198.00 (11.79%) 7,282,128.34 (8.14%)		25.42 *<0.0001*	3.39 *0.043*
missing	77.00 (5.16%) 2,542,182.95 (5.65%)		65.00 (3.87%) 3,681,415.78 (4.11%)			
Body Mass Index (bmi30cat)						
<30.0[R] underweight normal overweight	1,099.00 (73.61%) 33,131,937.89 (73.61%)		1,258.00 (74.88%) 69,711,959.03 (77.90%)			
30.0+ obese	379.00 (25.39%) 11,702,893.48 (26.00%)		398.00 (23.69%) 18,513,564.32 (20.69%)		2.25 *0.324*	2.49 *0.094*
missing	15.00 (1.00%) 175,315.20 (0.39%)		24.00 (1.43%) 1,266,363.51 (1.42%)			
Fat Intake/AMDR (fat3cat)						
recommended or less[R]	982.00 (65.82%) 28,732,213.69 (63.88%)		1,066.00 (63.57%) 57,947,502.11 (64.82%)			
more than recommended	510.00 (39.18%) 16,248,798.94 (36.12%)		611.00 (36.92%) 31,443,847.06 (35.18%)		1.75 *0.186*	0.03 *0.852*
Protein Intake/AMDR (prot3cat)						
recommended or more[R]	1,256.00 (84.13%) 39,216,304.71 (87.13%)		1,456.00 (86.67%) 79,547,460.56 (88.89%)			
less than recommended	237.00 (15.87%) 5,793,841.86 (12.87%)		224.00 (13.33%) 9,944,426.30 (11.11%)		4.11 *0.043*	0.46 *0.502*
Iron Intake/RDA (iron2cat)						
recommended or more[R]	1,167.00 (78.16%) 33,365,800.23 (74.13%)		1,347.00 (80.18%) 74,076,517.74 (82.77%)			
less than recommended	326.00 (21.84%) 11,644,346.33 (25.87%)		333.00 (19.82%) 15,415,369.12 (17.23%)		1.95 *0.163*	6.19 *0.017*
Calcium Intake/RDA (calc2cat)						
recommended or more[R]	310.00 (20.76%) 9,569,989.07 (21.26%)		330.00 (19.64%) 16,506,320.13 (18.44%)			
less than recommended	1,183.00 (79.24%) 35,440,157.50 (78.74%)		1,350.00 (80.36%) 72,985,566.73 (81.56%)		0.62 *0.432*	0.57 *0.454*

Table 63
Bivariate Analyses of Independent Variables on Sum of PCBs Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Selenium Intake/RDA (sele2cat)						
recommended or more^{R}	1,176.00 (78.77%) 35,992,279.96 (79.96%)		1,381.00 (82.20%) 76,653,111.85 (85.55%)		5.96 *0.015*	2.79 *0.102*
less than recommended	317.00 (21.23%) 9,017,866.61 (20.04%)		299.00 (17.80%) 12,838,775.01 (14.35%)			
Reproductive Status						
Current Pregnancy (pregnant)						
pregnant	235.00 (15.74%) 2,428,211.72 (5.39%)		156.00 (9.29%) 2,413,977.37 (2.70%)			
not pregnant^{R}	1,251.00 (83.79%) 42,277,463.15 (93.93%)		1,390.00 (82.74%) 84,099,055.79 (93.97%)		127.09 *<0.0001*	10.55 *0.0002*
missing	7.00 (0.47%) 304,471.69 (0.68%)		134.00 (7.98%) 2,978,853.71 (3.33%)			
Trimester of Pregnancy (tripcorr)						
not pregnant^{R}	1,258.00 (84.26%) 42,581,934.85 (94.61%)		1,523.00 (90.71%) 87,077,909.50 (97.30%)			
1st trimester	76.00 (5.09%) 870,852.45 (1.93%)		73.00 (4.35%) 1,120,713.66 (1.25%)		38.67 *<0.0001*	3.40 *0.026*
2nd trimester	85.00 (5.69%) 825,252.95 (1.83%)		47.00 (2.80%) 698,242.58 (0.78%)			
3rd trimester	74.00 (4.96%) 732,106.32 (1.63%)		36.00 (2.14%) 595,021.13 (0.66%)			
Ever Pregnant (tprg2cat)						
never pregnant^{R}	848.00 (56.80%) 26,236,692.94 (58.29%)		687.00 (40.89%) 33,328,404.04 (37.24%)		80.08 *<0.0001*	17.10 *0.0002*
one or more pregnancies	645.00 (43.20%) 18,773,453.63 (41.71%)		993.00 (59.11%) 56,163,482.82 (62.76%)			
Live Births (live)						
no live births^{R}	1,002.00 (67.11%) 29,467,862.71 (65.47%)		818.00 (48.69%) 37,952,375.50 (42.41%)		109.69 *<0.0001*	19.71 *0.0001*
one or more live births	491.00 (32.89%) 15,542,283.85 (34.53%)		862.00 (51.31%) 51,539,511.36 (57.59%)			
Ever Breastfed (brstfda)						
never breastfed^{R}	1,145.00 (76.69%) 32,986,168.84 (73.29%)		1,178.00 (70.12%) 58,968,153.46 (65.89%)		17.41 *<0.0001*	2.31 *0.136*
breastfed more than one month or currently	348.00 (23.31%) 12,023,977.72 (26.71%)		502.00 (29.88%) 30,523,733.41 (34.11%)			

Table 63
Bivariate Analyses of Independent Variables on Sum of PCBs Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Exposure-Related Attributes						
Acculturation						
Birthplace (born2cat)						
U.S.[R]	1,224.00 (81.98%) 38,922,414.29 (86.47%)		1,449.00 (86.25%) 81,381,282.52 (90.94%)		10.84 *0.001*	3.24 *0.079*
outside U.S.	269.00 (18.02%) 6,087,732.28 (13.53%)		231.00 (13.75%) 8,110,604.35 (9.06%)			
Years in U.S. (yrus5)						
born in U.S.[R]	1,224.00 (82.15%) 38,922,414.29 (86.63%)		1,449.00 (86.40%) 81,381,282.52 (91.03%)		13.75 *0.001*	3.15 *0.053*
five or more years	181.00 (12.15%) 4,358,326.80 (9.70%)		171.00 (10.20%) 6,715,192.41 (7.51%)			
les than five years	85.00 (5.70%) 1,649,779.74 (3.67%)		57.00 (3.40%) 1,306,187.17 (1.46%)			
Language Spoken at Home (lang2cat)						
English[R]	1,306.00 (87.47%) 40,964,135.78 (91.01%)		1,538.00 (91.66%) 85,797,058.59 (95.12%)		14.94 *0.0001*	11.75 *0.0013*
Other	187.00 (12.53%) 4,046,010.79 (8.99%)		140.00 (8.34%) 3,467,760.92 (3.88%)			
U.S. Citizenship (usczn2cat)						
U.S. citizen[R]	1,282.00 (85.87%) 41,083,030.09 (91.28%)		1,532.00 (91.24%) 85,742,241.82 (95.83%)		22.82 *<0.0001*	10.29 *0.0025*
non-U.S. citizen	211.00 (14.13%) 3,927,116.48 (8.72%)		147.00 (8.76%) 3,727,776.36 (4.17%)			
Diet						
Seafood Eaten in Past 30 Days (smpw2cat)						
none[R]	402.00 (26.93%) 11,642,905.87 (25.87%)		284.00 (16.90%) 11,227,934.91 (12.55%)		46.84 *<0.0001*	12.59 *0.0009*
any	1,091.00 (73.07%) 33,367,240.70 (74.13%)		1,396.00 (83.10%) 78,263,951.95 (87.45%)			
Fish Eaten in Past 30 Days (fish2cat)						
none[R]	574.00 (38.45%) 16,052,553.48 (35.66%)		466.00 (27.74%) 20,757,186.19 (23.19%)		41.14 *<0.0001*	6.04 *0.018*
any	919.00 (61.55%) 28,957,593.09 (64.34%)		1,214.00 (72.26%) 68,734,700.67 (76.81%)			

Table 63
Bivariate Analyses of Independent Variables on Sum of PCBs Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Shellfish Eaten in Past 30 Days (shell2cat)						
none[R]	801.00 (53.65%) 23,922,841.35 (53.15%)		756.00 (45.00%) 39,095,797.83 (43.69%)		23.67 *<0.0001*	3.59 *0.064*
any	692.00 (46.35%) 21,087,305.22 (46.85%)		924.00 (55.00%) 50,396,089.03 (56.31%)			
Tap Water Consumed Prior 24h (tap2kct)						
none[R]	568.00 (38.04%) 15,461,106.70 (34.35%)		561.00 (33.39%) 25,043,721.55 (27.98%)			
< 2,000 ml	735.00 (49.23%) 23,331,575.10 (51.84%)		803.00 (47.80%) 47,713,910.32 (53.32%)		38.19 *<0.0001*	3.03 *0.039*
2,000+ ml	132.00 (8.84%) 4,889,498.34 (10.86%)		163.00 (9.70%) 10,640,054.15 (11.89%)			
missing	58.00 (3.88%) 1,327,966.43 (2.95%)		153.00 (9.11%) 6,094,200.84 (6.81%)			
Alcohol Consumption						
Alcohol Consumption (retohuse)						
never, seldom drinker[R] *including 16-19 y/o*	1,009.00 (67.58%) 22,739,993.00 (50.52%)		734.00 (43.69%) 29,480,522.36 (32.94%)			
drinker	245.00 (16.41%) 9,429,807.16 (20.95%)		485.00 (28.87%) 31,240,272.41 (34.91%)		186.93 *<0.0001*	6.47 *0.001*
heavy drinker	201.00 (13.46%) 11,780,202.42 (26.17%)		354.00 (21.07%) 23,985,177.01 (26.80%)			
missing	38.00 (2.55%) 1,060,143.98 (2.36%)		107.00 (6.37%) 4,785,915.08 (5.25%)			
Tobacco Use						
Serum Cotinine (cot3cat)						
< 1.0 ng/ml[R]	1,123.00 (75.37%) 31,818,893.33 (70.72%)		1,245.00 (74.64%) 67,052,580.24 (75.44%)			
1.0 - 10.0 ng/ml	93.00 (6.24%) 2,059,773.91 (4.58%)		97.00 (5.82%) 3,190,527.70 (3.59%)		0.85 *0.655*	0.93 *0.404*
> 10.0 ng/ml	274.00 (18.39%) 11,112,927.46 (24.70%)		326.00 (19.54%) 18,637,413.77 (20.97%)			

Table 63
Bivariate Analyses of Independent Variables on Sum of PCBs Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
ETS (ETS)						
no ETS^{R}	1,140.00 (76.36%) 32,938,432.57 (73.18%)		1,277.00 (76.01%) 68,858,939.01 (76.94%)			
ETS at home or work	296.00 (19.83%) 9,460,507.36 (21.02%)		354.00 (21.07%) 17,246,362.24 (19.27%)		2.53 *0.282*	0.47 *0.629*
ETS at home and work	57.00 (3.82%) 2,611,206.64 (5.80%)		49.00 (2.92%) 3,386,585.61 (3.78%)			
Residence						
Tap Water Source (h2os2cat)						
public^{R}	1,341.00 (89.82%) 39,539,285.54 (87.85%)		1,485.00 (88.39%) 77,196,622.63 (86.26%)			
private	109.00 (7.30%) 4,324,982.72 (9.61%)		157.00 (9.35%) 10,166,552.30 (11.36%)		5.30 *0.070*	0.12 *0.886*
missing	43.00 (2.88%) 1,145,878.31 (2.55%)		38.00 (2.26%) 2,128,711.94 (2.38%)			
Residential Tap Water Treatment (h2ox2cat)						
yes	394.00 (26.39%) 14,750,534.69 (32.77%)		469.00 (27.92%) 30,557,699.97 (34.15%)			
no^{R}	1,063.00 (71.20%) 29,276,436.74 (65.04%)		1,176.00 (70.00%) 57,268,900.62 (63.99%)		1.22 *0.544*	0.59 *0.942*
missing	36.00 (2.41%) 983,175.13 (2.18%)		35.00 (2.08%) 1,665,286.27 (1.86%)			
Type of Residence (res3cat)						
attached or detached house^{R}	892.00 (59.75%) 24,693,788.16 (54.86%)		1,180.00 (70.24%) 64,612,182.40 (72.20%)			
mobile home or trailer	101.00 (6.76%) 3,878,638.25 (8.62%)		101.00 (6.01%) 4,523,139.55 (5.05%)		40.49 *<0.0001*	9.78 *0.0003*
all other types *including missing/unknown*	500.00 (33.49%) 16,437,720.16 (36.52%)		399.00 (23.75%) 20,356,564.91 (22.75%)			
Age of Residence (resb60cat)						
1960 or newer^{R}	677.00 (45.34%) 23,503,687.57 (52.22%)		918.00 (54.64%) 54,540,836.45 (60.95%)			
older than 1960	347.00 (23.24%) 9,775,894.29 (21.72%)		419.00 (24.94%) 22,316,305.81 (24.94%)		51.89 *<0.0001*	4.08 *0.024*
missing/unknown	469.00 (31.41%) 11,730,564.71 (26.06%)		343.00 (20.42%) 12,634,744.60 (14.12%)			

Table 63
Bivariate Analyses of Independent Variables on Sum of PCBs Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Age of Residence (resb78cat)						
1978 or newer^{R}	447.00 (29.94%) 16,360,463.61 (36.35%)		640.00 (38.10%) 39,027,585.24 (43.61%)			
older than 1978	577.00 (38.65%) 16,919,118.24 (37.59%)		697.00 (41.49%) 37,829,557.02 (42.27%)		54.29 *<0.0001*	4.09 *0.023*
missing/unknown	469.00 (31.41%) 11,730,564.71 (26.06%)		343.00 (20.42%) 12,634,744.60 (14.12%)			
Resident Status (resd3cat)						
own^{R}	734.00 (49.16%) 23,922,800.23 (53.15%)		993.00 (59.11%) 53,327,506.90 (59.59%)			
rent	651.00 (43.60%) 18,051,507.75 (40.11%)		627.00 (37.32%) 33,112,387.82 (37.00%)		42.13 *<0.0001*	1.21 *0.308*
other *including missing*	108.00 (7.23%) 3,035,838.58 (6.74%)		60.00 (3.57%) 3,051,992.15 (3.41%)			
Years at Current Residence (re5yrcat)						
more than five years^{R}	487.00 (32.62%) 13,709,926.15 (30.46%)		626.00 (37.26%) 32,184,392.54 (35.96%)			
five years or less	981.00 (65.71%) 30,721,629.00 (68.25%)		1,026.00 (61.07%) 55,733,983.94 (62.28%)		7.54 *0.023*	0.84 *0.440*
missing	25.00 (1.67%) 578,591.42 (1.29%)		28.00 (1.67%) 1,573,510.39 (1.76%)			
Household Size (hsize)						
four persons or less^{R}	927.00 (62.09%) 32,334,461.84 (71.84%)		1,255.00 (74.70%) 74,119,566.54 (82.82%)			
more than four persons	566.00 (37.91%) 12,675,684.72 (28.16%)		425.00 (25.30%) 15,372,320.32 (17.18%)		58.55 *<0.0001*	7.53 *0.0088*
Rooms in Residence (rm3cat)						
7+ rooms^{R}	493.00 (33.02%) 15,009,690.26 (33.35%)		655.00 (38.99%) 37,606,822.55 (42.02%)			
4-6 rooms	819.00 (54.86%) 25,056,886.05 (55.67%)		872.00 (51.90%) 44,043,246.54 (49.21%)		15.92 *0.001*	1.28 *0.293*
1-3 rooms	142.00 (9.51%) 3,897,280.19 (8.66%)		121.00 (7.20%) 6,277,892.92 (7.02%)			
missing	39.00 (2.61%) 1,046,290.06 (2.32%)		32.00 (1.90%) 1,563,924.86 (1.75%)			

Table 63
Bivariate Analyses of Independent Variables on Sum of PCBs Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Occupation						
Current Occupation (cocc2cat)						
not working^{R}	735.00 (49.23%) 17,142,933.21 (38.09%)		589.00 (35.06%) 25,030,024.37 (27.97%)			
management, professional & sales	469.00 (31.41%) 17,786,522.86 (39.52%)		774.00 (46.07%) 49,972,368.87 (55.84%)		81.49 *<0.0001*	6.85 *0.0026*
services & goods	289.00 (19.36%) 10,080,690.49 (22.40%)		317.00 (18.87%) 14,489,493.62 (16.19%)			
Time in Current Employment (cjt)						
not working^{R}	735.00 (49.23%) 17,142,933.21 (38.09%)		589.00 (35.06%) 25,030,024.37 (27.97%)			
less than five years	670.00 (44.88%) 24,183,444.33 (53.73%)		764.00 (45.48%) 43,058,195.40 (48.11%)		149.40 *<0.0001*	11.38 *0.0001*
five or more years	88.00 (5.89%) 3,683,769.03 (8.18%)		327.00 (19.46%) 21,403,667.10 (23.92%)			
Total Hours Worked Prior Week (hrwk)						
not employed^{R}	755.00 (50.57%) 17,890,767.05 (39.75%)		626.00 (37.31%) 27,917,270.98 (31.25%)			
less than 35 hours	353.00 (23.64%) 10,611,357.52 (23.58%)		383.00 (22.82%) 22,756,076.28 (25.47%)		79.27 *<0.0001*	1.51 *0.232*
35+ hours	385.00 (25.79%) 16,508,021.99 (36.68%)		669.00 (39.87%) 38,673,499.01 (43.28%)			
Longest Held Occupation (locc2cat)						
not applicable^{R}	701.00 (46.95%) 20,098,821.46 (44.65%)		861.00 (51.25%) 44,018,535.05 (49.19%)			
management, professional & sales	396.00 (26.52%) 12,437,060.19 (27.63%)		507.00 (30.18%) 28,978,125.96 (32.38%)		29.08 *<0.0001*	2.35 *0.107*
services & goods	396.00 (26.52%) 12,474,264.91 (27.71%)		312.00 (18.57%) 16,495,225.86 (18.43%)			
Time in Longest Employment (ljt)						
not applicable^{R}	701.00 (42.87%) 20,098,821.46 (44.65%)		861.00 (51.25%) 44,018,535.05 (49.19%)			
less than five years	640.00 (43.13%) 19,590,358.38 (43.52%)		357.00 (22.20%) 14,951,910.47 (16.71%)		243.06 *<0.0001*	18.58 *0.0000*
five or more years	152.00 (10.18%) 5,320,966.73 (11.82%)		462.00 (27.50%) 30,521,441.35 (34.11%)			

Table 63
Bivariate Analyses of Independent Variables on Sum of PCBs Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. unweighted Population Frequency Col. Pct. weighted R = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Work History (wkcp)						
never employed[R]	241.00 (16.14%) 3,806,816.77 (8.46%)		167.00 (9.94%) 4,431,994.03 (4.95%)			
currently employed	460.00 (30.81%) 16,292,004.69 (36.20%)		694.00 (41.31%) 39,586,541.02 (44.23%)		69.85 *<0.0001*	3.58 *0.021*
employed in the past but not currently	494.00 (33.09%) 13,336,116.44 (29.63%)		422.00 (24.12%) 20,598,030.34 (23.02%)			
employed now and in the past	298.00 (19.96%) 11,575,208.66 (25.72%)		397.00 (23.63%) 24,875,321.48 (27.80%)			
Socioeconomic Factors						
Education						
Highest Education (educ2)						
high school diploma, GED or higher[R]	812.00 (54.42%) 32,046,553.86 (71.30%)		1,225.00 (72.92%) 74,860,607.48 (83.65%)		117.61 *<0.0001*	11.33 *0.002*
less than high school diploma	680.00 (45.58%) 12,896,453.92 (28.70%)		455.00 (27.08%) 14,631,279.38 (16.35%)			
Employment						
Employment Status (emp3cat)						
employed	758.00 (50.84%) 27,867,213.36 (61.93%)		1,095.00 (65.18%) 64,601,586.61 (72.19%)		66.88 *<0.0001*	5.27 *0.026*
not employed[R]	733.00 (49.16%) 17,131,713.69 (38.07%)		585.00 (34.82%) 24,890,300.26 (27.81%)			
Reason for Unemployment (unem2cat)						
working[R]	758.00 (50.77%) 27,867,213.36 (61.91%)		1,095.00 (65.18%) 64,601,586.61 (72.19%)			
voluntary unemployment	524.00 (35.10%) 11,505,486.37 (25.56%)		400.00 (23.81%) 16,759,535.30 (18.73%)		102.69 *<0.0001*	2.29 *0.091*
involuntary unemployment	132.00 (8.84%) 3,668,819.47 (8.15%)		163.00 (9.70%) 6,594,294.54 (7.37%)			
missing	79.00 (5.29%) 1,968,627.37 (4.37%)		22.00 (1.31%) 1,536,470.42 (1.72%)			
Income						
U.S. Poverty Threshold (pov2cat)						
more than 1.00[R]	990.00 (66.31%) 32,255,606.34 (71.66%)		1,237.00 (73.63%) 71,698,016.85 (80.12%)		30.72 *<0.0001*	2.03 *0.144*
1.00 or less	409.00 (27.39%) 8,921,998.51 (19.82%)		321.00 (19.11%) 13,665,198.96 (15.27%)			
missing	94.00 (6.30%) 3,832,541.72 (8.51%)		122.00 (7.26%) 4,128,671.05 (4.61%)			

Table 63
Bivariate Analyses of Independent Variables on Sum of PCBs Among Childbearing-Aged Females
(unweighted and weighted data 1999-2004)

Independent Variables Sample Frequency Col. Pct. $_{unweighted}$ Population Frequency Col. Pct. $_{weighted}$ ^{R} = Reference Group * = cell size less than 30	Below Geometric Mean		At or Above Geometric Mean		χ^2 *p value unweighted*	χ^2 *p value weighted*
Marital Status						
Marital Status (marr3cat)						
	454.00		744.00			
	(30.41%)		(44.29%)			
	15,664,599.68		46,136,048.57			
married or living with partner	(34.80%)		(51.55%)			
	61.00		200.00			
	(4.09%)		(11.90%)			
	2,370,074.71		11,983,877.67		213.66	13.55
widowed, divorced or separated	(5.27%)		(13.39%)		*<0.0001*	*0.0000*
	963.00		674.00			
	(64.50%)		(40.12%)			
	26,043,831.55		27,449,119.94			
never married^{R}	(57.86%)		(30.67%)			
	15.00		62.00			
	(1.00%)		(3.69%)			
	931,640.64		3,922,840.67			
missing	(2.07%)		(4.28%)			
Race-Ethnicity						
Race-Ethnicity (race5cat)						
	625.00		868.00			
	(41.86%)		(51.67%)			
Non-Hispanic White^{R}	30,387,650.82		67,499,893.35			
$n_{unweighted}$ = 1493	(67.51%)		(75.43%)			
$n_{weighted}$ = 97,887,544.16						
	276.00		347.00			
	(18.49%)		(20.65%)			
Non-Hispanic Black	3,895,016.67		8,852,161.70			
$n_{unweighted}$ = 623	(8.65%)		(9.89%)			
$n_{weighted}$ = 12,747,178.37						
	430.00		315.00		69.45	3.55
	(28.80%)		(18.75%)		*<0.0001*	*0.014*
Mexican American	5,073,367.51		3,597,208.29			
$n_{unweighted}$ = 745	(11.27%)		(4.02%)			
$n_{weighted}$ = 8,670,575.80						
	109.00		69.00			
	(7.30%)		(4.11%)			
Other Hispanic	3,277,436.73		4,248,555.49			
$n_{unweighted}$ = 178	(7.28%)		(4.75%)			
$n_{weighted}$ = 7,525,992.22						
	53.00		81.00			
Asian, Native American, Pacific Islander	(3.55%)		(4.82%)			
& Multi-Racial	2,376,674.85		5,294,068.03			
$n_{unweighted}$ = 134	(5.28%)		(5.92%)			
$n_{weighted}$ = 7,670,742.88						
Race-Ethnicity/Hispanic Grouping (race4cat)						
	625.00		868.00			
	(41.86%)		(51.67%)			
Non-Hispanic White^{R}	30,387,650.82		67,499,893.35			
$n_{unweighted}$ = 1493	(67.51%)		(75.43%)			
$n_{weighted}$ = 97,887,544.16						
	276.00		347.00			
	(18.49%)		(20.65%)			
Non-Hispanic Black	3,895,016.67		8,852,161.70		68.74	3.58
$n_{unweighted}$ = 623	(8.65%)		(9.89%)		*<0.0001*	*0.021*
$n_{weighted}$ = 12,747,178.37						
	539.00		384.00			
	(36.10%)		(22.86%)			
Hispanic	8,350,804.24		7,845,763.79			
$n_{unweighted}$ = 923	(18.55%)		(8.77%)			
$n_{weighted}$ = 16,196,568.02						
	53.00		81.00			
Asian, Native American, Pacific Islander	(3.55%)		(4.82%)			
& Multi-Racial	2,376,674.85		5,294,068.03			
$n_{unweighted}$ = 134	(5.28%)		(5.92%)			
$n_{weighted}$ = 7,670,742.88						

Table 64
Summary of Chi-Square and *p* Values of Weighted Independent Variables on Sum of PCBs (1999-2004)

Variables *p < 0.20*	*p* value	χ^2 *weighted*	Variables *p > 0.20*	*p* value	χ^2 *weighted*
Age (age4cat)	*0.0000*	26.44	Regular Source of Healthcare (hp2cat)	*0.226*	1.51
Time in Longest Employment (ljt)	*0.0000*	18.58	Iron Deficiency and Treatment (FeDTx)	*0.228*	1.49
Marital Status (marr3cat)	*0.0000*	13.55	Total Hours Worked Prior Week (hrwk)	*0.232*	1.51
Live Births (live)	*0.0001*	19.71	Rooms in Residence (rm3cat)	*0.293*	1.28
Time in Current Employment (cjt)	*0.0001*	11.38	Resident Status (resd3cat)	*0.308*	1.21
Ever Pregnant (tprg2cat)	*0.0002*	17.10	Serum Cotinine (cot3cat)	*0.404*	0.93
Current Pregnancy (pregnant)	*0.0002*	10.55	Years at Current Residence (re5yrcat)	*0.440*	0.84
Type of Residence (res3cat)	*0.0003*	9.78	Perceived Health Status (huq2cat)	*0.443*	0.59
Seafood in Past 30 Days [1] (smpw2cat)	*0.0009*	12.59	Calcium Intake/RDA (calc2cat)	*0.454*	0.57
Alcohol Consumption (retohuse)	*0.0010*	6.47	Protein Intake/AMDR (prot3cat)	*0.502*	0.46
Language Spoken at Home (lang2cat)	*0.0013*	11.75	Iron Deficiency (FeD2cat)	*0.516*	0.43
Highest Education (educ2)	*0.0016*	11.33	Charleson Co-Morbidity Scale (CCMS3cat)	*0.626*	0.47
U.S. Citizenship (usczn2cat)	*0.0025*	10.29	Environmental Tobacco Smoke (ETS)	*0.629*	0.47
Current Occupation[1] (cocc2cat)	*0.0026*	6.85	Fat Intake/AMDR (fat3cat)	*0.852*	0.03
Household Size (hsize)	*0.0088*	7.53	Tap Water Source (h2os2cat)	*0.886*	0.12
Race-Ethnicity[1] (race5cat)	*0.014*	3.55	Residential Tap Water Treatment (h2ox2cat)	*0.942*	0.59
Iron Intake/RDA[1] (iron2cat)	*0.017*	6.19			
Fish in Past 30 Days (fish2cat)	*0.018*	6.04			
Work History[1] (wkcp)	*0.021*	3.58			
Race-Ethnicity/Hispanic Grouping (race4cat)	*0.021*	3.58			
Age of Residence (resb78cat)	*0.023*	4.09			
Age of Residence (resb60cat)	*0.024*	4.08			
Health Insurance (hi2cat)	*0.025*	3.44			
Employment Status (emp3cat)	*0.026*	5.27			
Trimester of Pregnancy[1] (tripcorr)	*0.026*	3.40			
Tap Water Consumed 24h (tap2kct)	*0.039*	3.03			
Food Security (food2cat)	*0.043*	3.39			
Years in U.S. (yrus5)	*0.053*	3.15			
Shellfish in Past 30 Days (shell2cat)	*0.064*	3.59			

[1]variable dropped due to low cell size or too similar to other variables

Table 64
Summary of Chi-Square and *p* Values of Weighted Independent Variables on Sum of PCBs (1999-2004)

Variables *p < 0.20*	*p* value	χ^2 *weighted*	Variables *p > 0.20*	*p* value	χ^2 *weighted*
Birthplace[1] (born2cat)	*0.079*	3.24			
Reason for Unemployment[1] (unem2cat)	*0.091*	2.29			
Body Mass Index (bmi30cat)	*0.094*	2.49			
Treatment for Iron Deficiency[1] (FeTx2cat)	*0.096*	2.89			
Selenium Intake/RDA (sele2cat)	*0.102*	2.79			
Longest Held Occupation[1] (locc2cat)	*0.107*	2.35			
Source of Healthcare[1] (hcsre)	*0.114*	2.09			
Ever Breastfed (brstfda)	*0.136*	2.31			
U.S. Poverty Threshold[1] (pov2cat)	*0.144*	2.03			

[1]variable dropped due to low cell size or too similar to other variables

Table 65
Stepwise Logistic Regression Analyses of Sum of PCBs (1999-2004)

Variable Name *p < 0.20*	df	-2LL Wald F	Difference	df	*p* value
Initial Regression	41	1,366.79			
1 Time in Current Employment (cjt)	39	1,366.64	0.15	2	*>0.20* *drop*
2 Health Insurance (hi2cat)	36	1,365.14	1.50	3	*>0.20* *drop*
3 Alcohol Consumption (retohuse)	33	1,360.90	4.24	3	*>0.20* *drop*
4 Marital Status (marr3cat)	30	1,352.84	8.06	3	*<0.05* *keep*
5 Highest Education (educ2)	32	1,363.12	2.22	1	*>0.10* *drop*
6 Race-Ethnicity/Hispanic Grouping (race4cat)	29	1,354.53	8.59	3	*<0.05* *keep*
7 Selenium Intake/RDA (sele2cat)	31	1,360.94	2.18	1	*>0.10* *drop*
8 Language Spoken at Home (lang2cat)	30	1,356.49	4.45	1	*<0.05* *keep*
9 Years in U.S. (yrus5)	29	1,350.69	10.25	2	*<0.01* *keep*
10 U.S. Citizenship (usczn2cat)	30	1,359.07	1.87	1	*>0.01* *drop*
11 Time in Longest Employment (ljt)	28	1,263.41	95.66	2	*<0.001* *keep*
12 Household Size (hsize)	29	1,335.03	6.04	1	*<0.02* *keep*
13 Age of Residence 1978 (resb78cat)	28	1,315.03	44.04	2	*<0.001* *keep*
14 Type of Residence (res3cat)	28	1,328.02	31.05	2	*<0.001* *keep*
15 Tap Water Consumed 24h (tap2kct)	29	1,342.54	16.53	1	*<0.001* *keep*
16 Shellfish in Past 30 Days (shell2cat)	31	1,362.33	3.26	1	*>0.05* *drop*
17 Fish in Past 30 Days (fish2cat)	30	1,333.34	28.99	1	*<0.001* *keep*
18 Age (age4cat)	28	974.94	387.39	3	*<0.001* *keep*

Table 66
Best-Fit Logistic Regression PCBs Model *with no interactions* (1999-2004)

Variable Name	df	-2LL Wald F	R^2		*p* value
Best Fit Regression	31	1,362.33	*0.3498*		
Age (age4cat)	3	29.97			*0.0000*
Body Mass Index (bmi30cat)	2	11.50			*0.0001*
Current Pregnancy (pregnant)	2	10.37			*0.0002*
Time in Longest Employment (ljt)	2	10.32			*0.0002*
Ever Breastfed (brstfda)	1	13.61			*0.0006*
Type of Residence (res3cat)	2	6.07			*0.0047*
Household Size (hsize)	1	6.70			*0.0130*
Live Births (live)	1	6.36			*0.0154*
Tap Water Consumed 24h (tap2kct)	3	3.78			*0.0170*
Fish in Past 30 Days (fish2cat)	1	4.52			*0.0392*
Age of Residence 1978 (resb78cat)	2	2.77			*0.0739*
Food Security (food2cat)	2	2.76			*0.0744*
Years in U.S. (yrus5)	2	2.45			*0.0981*
Language Spoken at Home (lang2cat)	1	1.64			*0.2074*
Race-Ethnicity/Hispanic Grouping (race4cat)	3	0.75			*0.5304*
Marital Status (marr3cat)	3	0.72			*0.5435*

[1]in ascending order by p value

Table 65
Stepwise Logistic Regression Analyses of Sum of PCBs (1999-2004)

Variable Name *p < 0.20*	df	-2LL Wald F	Difference	df	*p* value
19 Food Security (food2cat)	29	1,343.08	19.25	2	*<0.001* *keep*
20 Body Mass Index (bmi30cat)	29	1,245.42	116.91	2	*<0.001* *keep*
21 Current Pregnancy (pregnant)	29	1,277.07	85.26	2	*<0.001* *keep*
22 Live Births (live)	30	1,345.88	16.45	1	*<0.001* *keep*
23 Ever Breastfed (brstfda)	30	1,309.47	52.86	1	*<0.001* *keep*

Table 66
Best-Fit Logistic Regression PCBs Model *with no interactions* (1999-2004)

Variable Name	df	-2LL Wald F	R^2		*p* value

Table 67
Variance Inflation Factor Test for Collinearity Among Independent Variables using the Best-Fit Logistic Regression PCBs Model (1999-2004)

	df	sum of squares	mean square	F value	pr>F	
Best Fit PCBs Model *with no interactions*	16	118.561	7.410	55.32	*<0.0001*	

Variable Name	df	parameter estimate	std error	t value	pr>t	VIF
Intercept	1	0.053	0.033	1.61	*0.1085*	0.0000
Age (age4cat)	1	0.044	0.003	14.99	*<0.0001*	1.9151
Food Security (food2cat)	1	-0.019	0.005	-4.13	*<0.0001*	1.0533
Body Mass Index (bmi30cat)	1	-0.038	0.005	-7.09	*<0.0001*	1.0488
Current Pregnancy (pregnant)	1	0.050	0.005	9.98	*<0.0001*	1.6317
Live Births (live)	1	0.032	0.010	3.19	*0.0014*	2.8670
Ever Breastfed (brstfda)	1	-0.043	0.011	-3.87	*0.0001*	2.3533
Years in U.S. (yrus5)	1	-0.008	0.006	-1.31	*0.1917*	2.1005
Language Spoken at Home (lang2cat)	1	-0.032	0.011	-2.95	*0.0032*	2.0401
Fish in Past 30 Days (fish2cat)	1	0.059	0.006	10.68	*<0.0001*	1.2683
Tap Water Consumed 24h (tap2kct)	1	-0.002	0.003	-0.58	*0.5599*	1.0307
Type of Residence (res3cat)	1	0.002	0.003	0.71	*0.4789*	1.1747
Age of Residence (resb78cat)	1	0.008	0.003	2.50	*0.0125*	1.1597
Household Size (hsize)	1	-0.008	0.005	-1.49	*0.1360*	1.1343
Time in Longest Employment (ljt)	1	0.003	0.003	0.88	*0.3814*	1.0483
Marital Status (marr3cat)	1	-0.010	0.003	-3.06	*0.0022*	1.8336
Race-Ethnicity/Hispanic Grouping (race4cat)	1	-0.001	0.003	-0.50	*0.6193*	1.2783

Table 68
Statistical Significance of Interactions Between Independent Variables using the Best-Fit Logistic Regression PCBs Model (1999-2004)

Independent Variables	Age (age4cat)	Food Security (food2cat)	Body Mass Index (bmi30cat)	Current Pregnancy (pregnant)	Live Births (live)	Ever Breastfed (brstfda)	Years in U.S. (yrus5)	Language Spoken at Home (lang2cat)	Fish in Past 30 Days (fish2cat)	Tap Water Consumed 24h (tap2ket)	Type of Residence (res3cat)	Age of Residence 1978 (resb78cat)	Household Size (hsize)	Time in Longest Employment (ljt)	Marital Status (marr3cat)	Race-Ethnicity Hispanic Grouping (race4cat)
Age (age4cat)																
Food Security (food2cat)	*<0.001*															
Body Mass Index (bmi30cat)	*op*	*op*														
Current Pregnancy (pregnant)	*op*	*op*	*op*													
Live Births (live)	*ns*	*ns*	*op*	*ns*												
Ever Breastfed (brstfda)	*ns*	*<0.01*	*op*	*ns*	*op*											
Years in U.S. (yrus5)	*ns*	*<0.01*	*op*	*op*	*ns*	*ns*										
Language Spoken at Home (lang2cat)	*<0.01*	*ns*	*ns*	*<0.05*	*ns*	*ns*	*<0.05*									
Fish in Past 30 Days (fish2cat)	*ns*	*<0.01*	*<0.001*	*ns*	*<0.05*	*ns*	*<0.02*	*<0.02*								
Tap Water Consumed 24h (tap2ket)	*<0.001*	*<0.001*	*<0.001*	*op*	*<0.001*	*<0.001*	*op*	*<0.01*	*<0.001*							
Type of Residence (res3cat)	*<0.001*	*op*	*op*	*op*	*ns*	*ns*	*<0.02*	*ns*	*<0.02*	*<0.01*						
Age of Residence 1978 (resb78cat)	*<0.001*	*<0.01*	*ns*	*ns*	*<0.01*	*<0.02*	*<0.05*	*ns*	*<0.001*	*ns*	*<0.01*					
Household Size (hsize)	*<0.02*	*ns*	*ns*	*ns*	*ns*	*<0.05*	*ns*	*<0.02*	*ns*	*<0.01*	*<0.001*	*<0.001*				
Time in Longest Employment (ljt)	*<0.001*	*<0.001*	*<0.01*	*op*	*<0.01*	*<0.01*	*<0.001*	*<0.001*	*<0.05*	*<0.001*	*<0.001*	*<0.001*	*<0.02*			
Marital Status (marr3cat)	*op*	*op*	*op*	*op*	*<0.001*	*<0.001*	*ns*	*ns*	*<0.001*	*op*	*<0.001*	*<0.001*	*<0.001*	*<0.001*		
Race-Ethnicity/Hispanic Grouping (race4cat)	*op*	*<0.001*	*op*	*op*	*ns*	*<0.001*	*op*	*ns*	*<0.001*	*<0.001*	*<0.001*	*ns*	*ns*	*<0.001*	*op*	

op = over parameterized unable to calculate
ns = not statistically significant p>0.05

Table 69
Odds Ratios and Confidence Intervals for Best-Fit Logistic Regression PCBs Model *with no interactions*
(1999-2004)

Variable Names	df	-2LL Wald F	*p* value	Odds Ratios	Confidence Intervals
Susceptibility-Related Attributes					
Age (age4cat)	3	29.97	*0.0000*		
16-19[R]				1.00	*ns*
20-29				2.75	1.42 - 5.31 %
30-39				7.31	3.55 - 15.06 %
40-49				95 27	35.91 - 252.78 %
Nutritional Status					
Food Security (food2cat)	2	2.76	*0.0744*		
food secure[R]				1.00	*ns*
food insecure				0.56	0.30 - 1.06 %
missing				1.64	0.46 - 5.82 %
Body Mass Index (bmi30cat)	2	11.50	*0.0001*		
<30.0[R] underweight, normal, overweight				1.00	*ns*
30.0+ obese				0.26	0.14 - 0.48 %
missing				5.13	0.08 - 328.61 %
Reproductive Status					
Current Pregnancy (pregnant)	2	10.37	*0.0002*		
pregnant				0.61	0.28 - 1.30 %
not pregnant[R]				1.00	*ns*
missing				25.23	5.62 - 113.27 %
Live Births (live)	1	6.36	*0.0154*		
no live births[R]				1.00	*ns*
one or more live births				2.16	1.17 - 3.99 %
Ever Breastfed (brstfda)	1	13.61	*0.0006*		
never breastfed[R]				1.00	*ns*
breastfed more than one month or currently				0.27	0.13 - 0.55 %
Exposure-Related Attributes					
Acculturation					
Years in U.S. (yrus5)	2	2.45	*0.0981*		
born in U.S.[R]				1.00	*ns*
five or more years				0.46	0.20 - 1.04 %
less than five years				1.02	0.24 - 4.31 %
Language Spoken at Home (lang2cat)	1	1.64	*0.2074*		
English[R]				1.00	*ns*
Other				0.53	0.20 - 1.44 %
Diet					
Fish in Past 30 Days (fish2cat)	1	4.52	*0.0392*		
none[R]				1.00	*ns*
any				1.83	1.03 - 3.24 %

[R] = referent group
ns = not significant

Table 69
Odds Ratios and Confidence Intervals for Best-Fit Logistic Regression PCBs Model *with no interactions*
(1999-2004)

Variable Names	df	-2LL Wald F	*p* value	Odds Ratios	Confidence Intervals
Tap Water Consumed 24h (tap2kct)	3	3.78	*0.0170*		
none[R]				1.00	*ns*
< 2,000 ml				0.80	0.44 - 1.45 %
2,000+ ml				0.88	0.37 - 2.14 %
missing				3.02	1.06 - 8.60 %
Residence					
Type of Residence (res3cat)	2	6.07	*0.0047*		
attached or detached house[R]				1.00	*ns*
mobile home or trailer				0.27	0.13 - 0.58 %
all other types *including missing/unknown*				0.89	0.52 - 1.52 %
Age of Residence 1978 (resb78cat)	2	2.77	*0.0739*		
1978 or newer[R]				1.00	*ns*
older than 1978				0.81	0.56 - 1.16 %
missing/unknown				0.38	0.15 - 0.92 %
Household Size (hsize)	1	6.70	*0.0130*		
four persons or less[R]				1.00	*ns*
more than four persons				0.53	0.32 - 0.87 %
Occupation					
Time in Longest Employment (ljt)	2	10.32	*0.0002*		
not applicable[R]				1.00	*ns*
less than five years				0.48	0.31 - 0.75 %
five or more years				1.92	0.78 - 4.71 %
Socioeconomic Factors					
Marital Status					
Marital Status (marr3cat)	3	0.72	*0.5435*		
married or living with partner				1.17	0.65 - 2.12 %
widowed, divorced or separated				1.11	0.52 - 2.36 %
never married[R]				1.00	*ns*
missing				2.66	0.66 - 10.75 %
Race-Ethnicity					
Race-Ethnicity/Hispanic Grouping (race4cat)	3	0.75	*0.5304*		
Non-Hispanic White[R]				1.00	*ns*
Non-Hispanic Black				1.63	0.77 - 3.49 %
Hispanic				0.96	0.41 - 2.29 %
Asian, Native American, Pacific Islander & Multi-Racial				1.41	0.55 - 3.62 %

[R] = referent group
ns = not significant

Table 70
Comparisons Among Logistic Regression Models for Exposure as Outcome with Two Categories, Lead, Methylmercury and PCBs *with no interactions* (1999-2004)

Category	Exposure: Best Fit Model *with no interactions*				Lead: Best Fit Model *with no interactions*				Methylmercury Best Fit Model *with no interactions*				PCBs: Best Fit Model *with no interactions*			
	Variable Name	df	-2LL Wald F	*p* value	Variable Name	df	-2LL Wald F	*p* value	Variable Name	df	-2LL Wald F	*p* value	Variable Name	df	-2LL Wald F	*p* value
	Best Fit Regression	24	1,002.16	$r^2 = 0.2719$	Best Fit Regression	31	965.55	$r^2 = 0.2636$	Best Fit Regression	25	845.61	$r^2 = 0.2340$	Best Fit Regression	31	1,362.33	$r^2 = 0.3498$
Age																
Age	Age (age4cat)	3	11.92	*0.0000*	Age (age4cat)	3	6.12	*0.0014*	Age (age4cat)	3	3.02	*0.0395*	Age (age4cat)	3	29.97	*0.0000*
Health Status																
Perceived Health Status									Perceived Health Status (huq2cat)	1	5.62	*0.0222*				
Charleson Co-Morbidity					Charleson Co-Morbidity Scale (CCMS3cat)	2	0.44	*0.6481*								
Health Insurance					Health Insurance (hi2cat)	3	4.18	*0.0109*								
Nutritional Status																
Food Security	Food Security (food2cat)	2	5.94	*0.0052*									Food Security (food2cat)	2	2.76	*0.0744*
Body Mass Index									Body Mass Index (bmi30cat)	2	1.22	*0.3056*	Body Mass Index (bmi30cat)	2	11.50	*0.0001*
Protein Intake/AMDR					Protein Intake/AMDR (prot3cat)	1	1.92	*0.1727*								
Selenium Intake/AMDR	Selenium Intake/RDA (sele2cat)	1	2.44	*0.1255*					Selenium Intake/RDA (sele2cat)	1	2.56	*0.1165*				
Reproductive Status																
Current Pregnancy					Current Pregnancy (pregnant)	2	4.96	*0.0114*	Current Pregnancy (pregnant)	2	2.49	*0.0949*	Current Pregnancy (pregnant)	2	10.37	*0.0002*
Live Births													Live Births (live)	1	6.36	*0.0154*
Ever Breastfed more than one month	Ever Breastfed (brstfda)	1	5.32	*0.0258*									Ever Breastfed (brstfda)	1	13.61	*0.0006*
Acculturation																
Years in U.S.													Years in U.S. (yrus5)	2	2.45	*0.0981*
Language Spoken at Home													Language Spoken at Home (lang2cat)	1	1.64	*0.2074*
U.S. Citizenship					U.S. Citizenship (usczn2cat)	1	29.11	*0.0000*								
Diet																
Fish Past 30 Days	Fish Eaten in Past 30 Days (fish2cat)	1	26.26	*0.0000*					Fish in Past 30 Days (fish2cat)	1	49.55	*0.0000*	Fish in Past 30 Days (fish2cat)	1	4.52	*0.0392*
Shellfish Past 30 Days	Shellfish Eaten in Past 30 Days (shell2cat)	1	3.73	*0.0598*					Shellfish in Past 30 Days (shell2cat)	1	7.84	*0.0076*				
Tap Water Consumed 24h									Tap Water Consumed 24h (tap2kct)	3	1.66	*0.1898*	Tap Water Consumed 24h (tap2kct)	3	3.78	*0.0170*
Alcohol Consumption																
Alcohol Consumption	Alcohol Consumption (retohuse)	3	1.60	*0.2020*	Alcohol Consumption (retohuse)	3	3.59	*0.0209*	Alcohol Consumption (retohuse)	3	1.24	*0.3081*				
Tobacco Use																
Serum Cotinine	Serum Cotinine (cot3cat)	2	1.37	*0.2641*	Serum Cotinine (cot3cat)	2	5.16	*0.0097*								

Table 70
Comparisons Among Logistic Regression Models for Exposure as Outcome with Two Categories, Lead, Methylmercury and PCBs*with no interactions* (1999-2004)

Category	Exposure: Best Fit Model *with no interactions*				Lead: Best Fit Model *with no interactions*				Methylmercury Best Fit Model *with no interactions*				PCBs: Best Fit Model *with no interactions*			
	Variable Name	df	-2LL Wald F	*p* value	Variable Name	df	-2LL Wald F	*p* value	Variable Name	df	-2LL Wald F	*p* value		df	-2LL Wald F	*p* value
Residence																
Type of Residence					Type of Residence (res3cat)	2	1.62	*0.2089*	Type of Residence (res3cat)	2	3.47	*0.0397*	Type of Residence (res3cat)	2	6.07	*0.0047*
Age of Residence 1960					Age of Residence 1960 (resb60cat)	2	6.26	*0.0041*								
Age of Residence 1978													Age of Residence 1978 (resb78cat)	2	2.77	*0.0739*
Household Size	Household Size (hsize)	1	1.55	*0.2193*					Household Size (hsize)	1	1.65	*0.2057*	Household Size (hsize)	1	6.70	*0.0130*
Occupation																
Time Current Employment					Time in Current Employment (cjt)	2	0.97	*0.3877*								
Total Hours Worked					Total Hours Worked Prior Week (hrwk)	2	0.20	*0.8160*								
Time Longest Employment	Time in Longest Employment (ljt)	2	1.68	*0.1976*					Time in Longest Employment (ljt)	2	2.42	*0.1011*	Time in Longest Employment (ljt)	2	10.32	*0.0002*
Education																
Highest Education	Highest Education (educ2)	1	3.81	*0.0572*												
Marital Status																
Marital Status	Marital Status (marr3cat)	3	2.13	*0.1106*	Marital Status (marr3cat)	3	2.29	*0.0917*					Marital Status (marr3cat)	3	0.72	*0.5435*
Race-Ethnicity																
Race-Ethnicity/Hispanic	Race-Ethnicity/Hispanic Grouping (race4cat)	3	0.96	*0.4210*	Race-Ethnicity/Hispanic Grouping (race4cat)	3	3.36	*0.0269*	Race-Ethnicity/Hispanic Grouping (race4cat)	3	0.53	*0.6645*	Race-Ethnicity/Hispanic Grouping (race4cat)	3	0.75	*0.5304*

Table 71
Odds Ratios and Confidence Intervals for Current Pregnancy in Four Best-Fit Logistic Regression Models *with no interactions* (1999-2004)

Variable	Exposure Model		Lead Model		Methylmercury Model		PCBs Model	
	Odds Ratios (95% CI)	Confidence Intervals	Odds Ratios	Confidence Intervals	Odds Ratios	Confidence Intervals	Odds Ratios	Confidence Intervals
Current Pregnancy (pregnant)								
pregnant	NA	NA	0.31	0.14 - 0.65 %	0.65	0.37 - 1.11 %	0.61	0.28 - 1.30 %
not pregnant[R]	NA	NA	1.00	*ns*	1.00	*ns*	1.00	*ns*
missing	NA	NA	1.23	0.45 - 3.36 %	0.24	0.03 - 2.06 %	25.23	5.62 - 113.27 %

Table 72
Odds Ratios and Confidence Intervals for Age in Four Best-Fit Logistic Regression Models *with no interactions* (1999-2004)

Variable	Exposure Model		Lead Model		Methylmercury Model		PCBs Model	
	Odds Ratios	Confidence Intervals	Odds Ratios	Confidence Intervals	Odds Ratios	Confidence Intervals	Odds Ratios	Confidence Intervals
Age (age4cat)								
16-19[R]	1.00	*ns*	1.00	*ns*	1.00	*ns*	1.00	*ns*
20-29	3.50	1.56 - 7.85	0.87	0.47 - 1.63 %	2.32	1.30 - 4.14 %	2.75	1.42 - 5.31 %
30-39	8.48	3.16 - 22.74	1.60	0.70 - 3.68 %	2.14	1.17 - 3.93 %	7.31	3.55 - 15.06 %
40-49	30.20	8.36 - 109.15	4.31	1.93 - 9.62 %	2.11	1.06 - 4.22 %	95 27	35.91 - 252.78 %

Table 73
Birth Cohorts by Age and Survey Years (1999 - 2004)

Age	1999	2001	2003	1999 - 2004
16 - 19	1980 - 1989	1982 - 1991	1984 - 1993	1980 - 1993
20 - 29	1970 - 1979	1972 - 1981	1974 - 1983	1970 - 1983
30 - 39	1960 - 1969	1962 - 1971	1964 - 1973	1960 - 1973
40 - 49	1950 - 1959	1952 - 1961	1954 - 1963	1950 - 1963

FIGURE 3

HISTOGRAM OF LOG DETECTABLE LEAD (1999-2000)

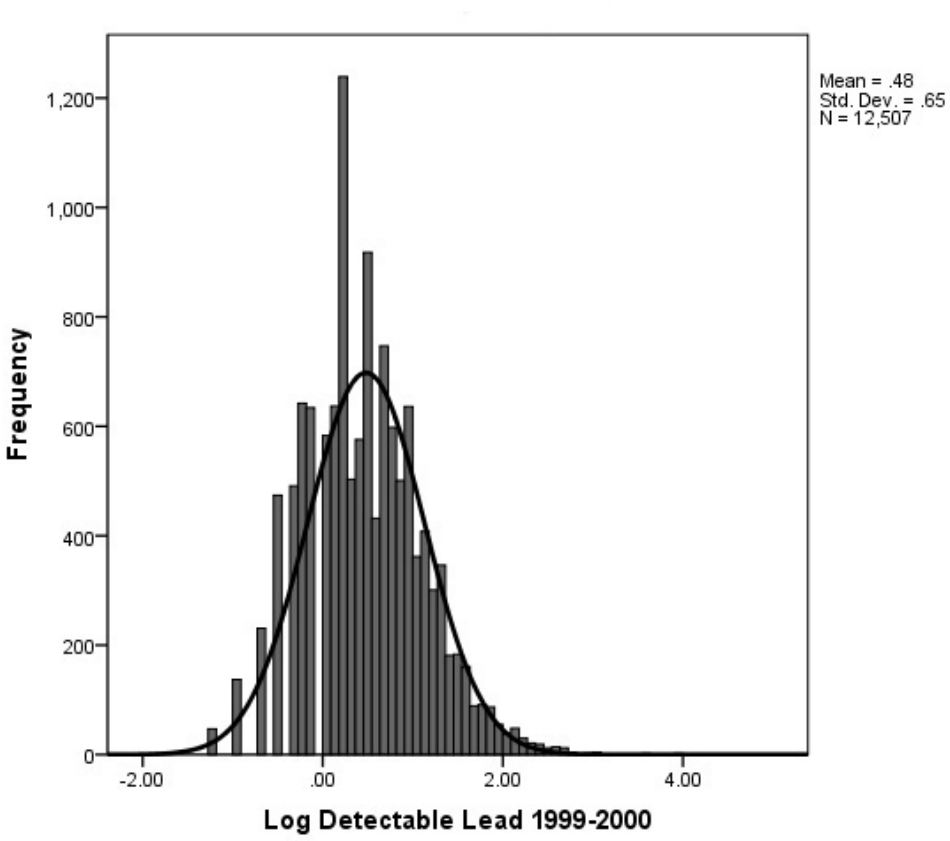


FIGURE 4

HISTOGRAM OF LOG DETECTABLE LEAD (2001-2002)

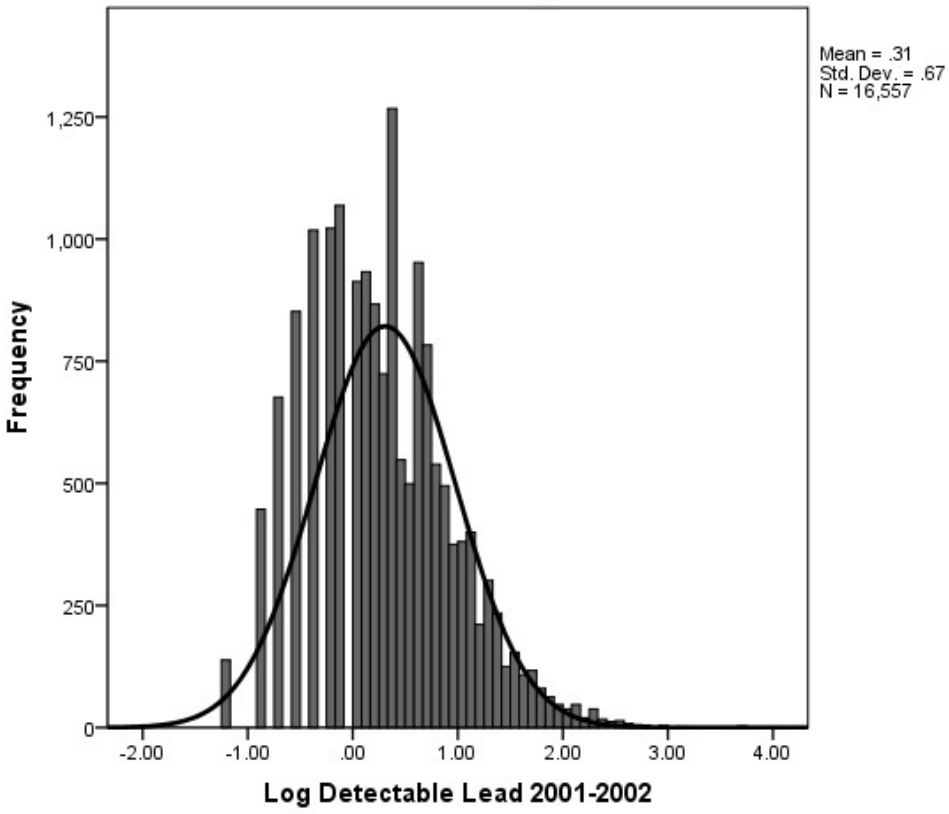


FIGURE 5

HISTOGRAM OF LOG DETECTABLE LEAD (2003-2004)

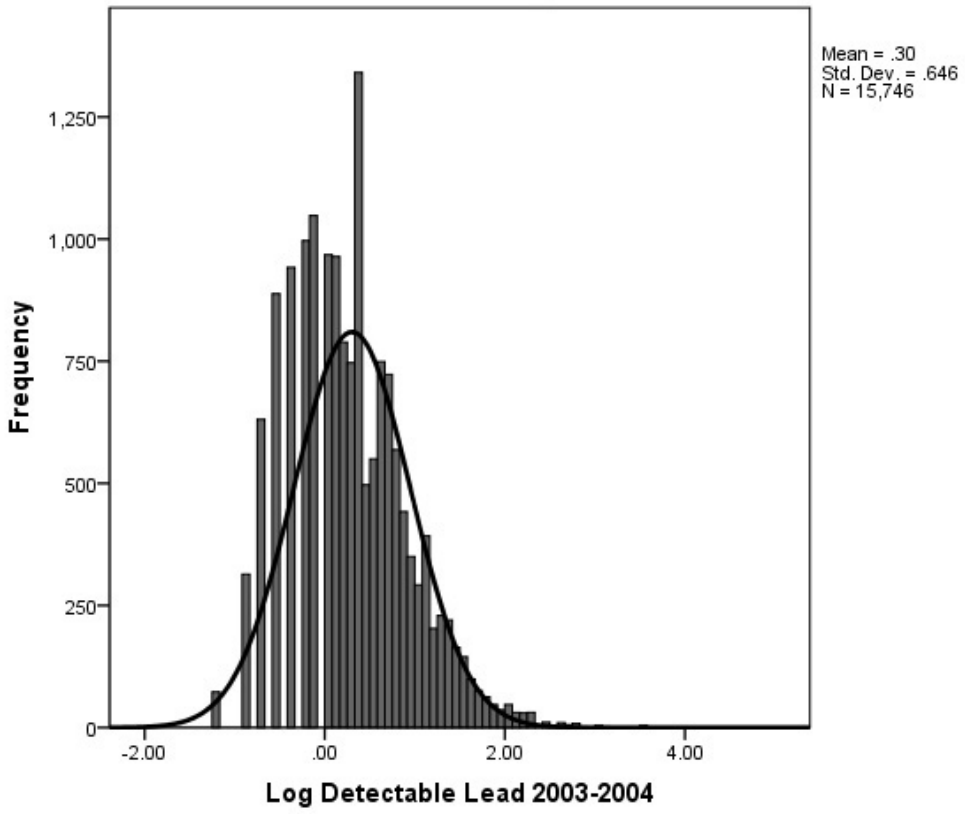


FIGURE 6

HISTOGRAM OF LOG DETECTABLE TOTAL MERCURY (1999-2000)

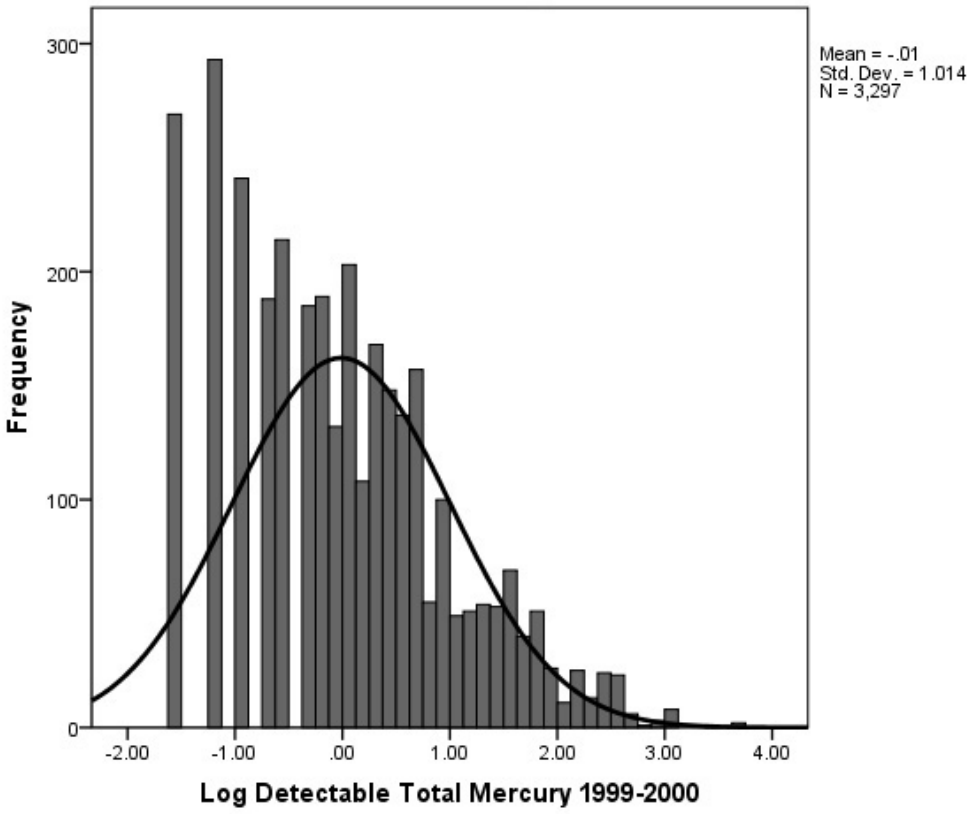


FIGURE 7

HISTOGRAM OF LOG DETECTABLE TOTAL MERCURY (2001-2002)

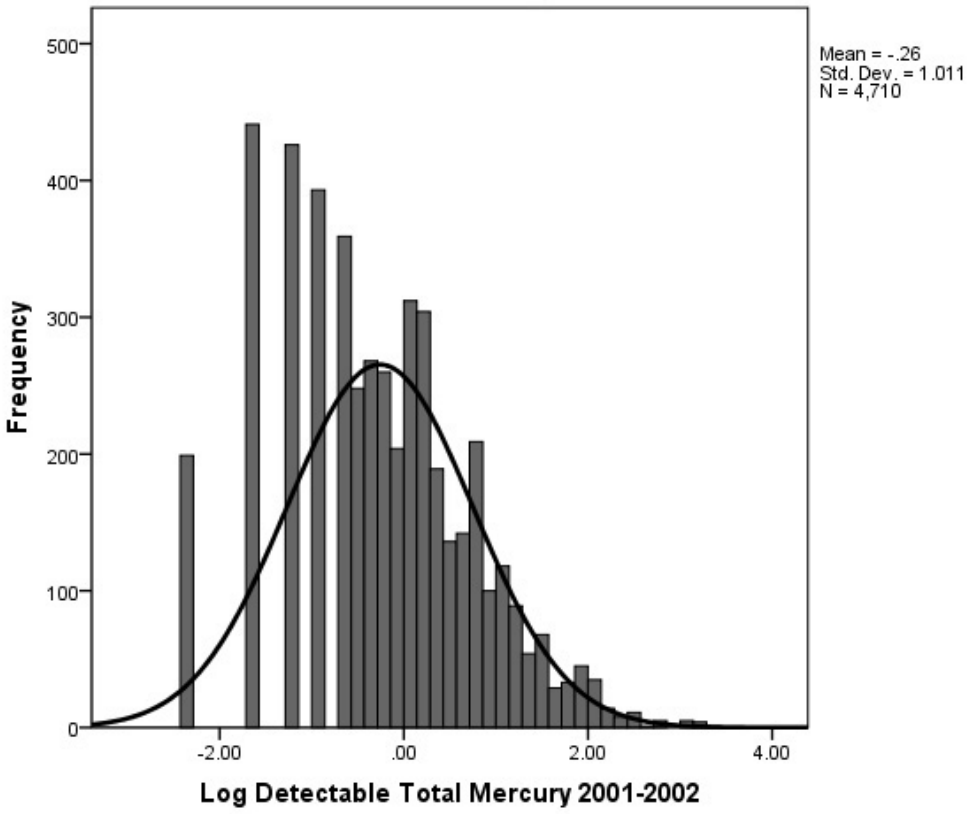


FIGURE 8

HISTOGRAM OF LOG DETECTABLE TOTAL MERCURY (2003-2004)

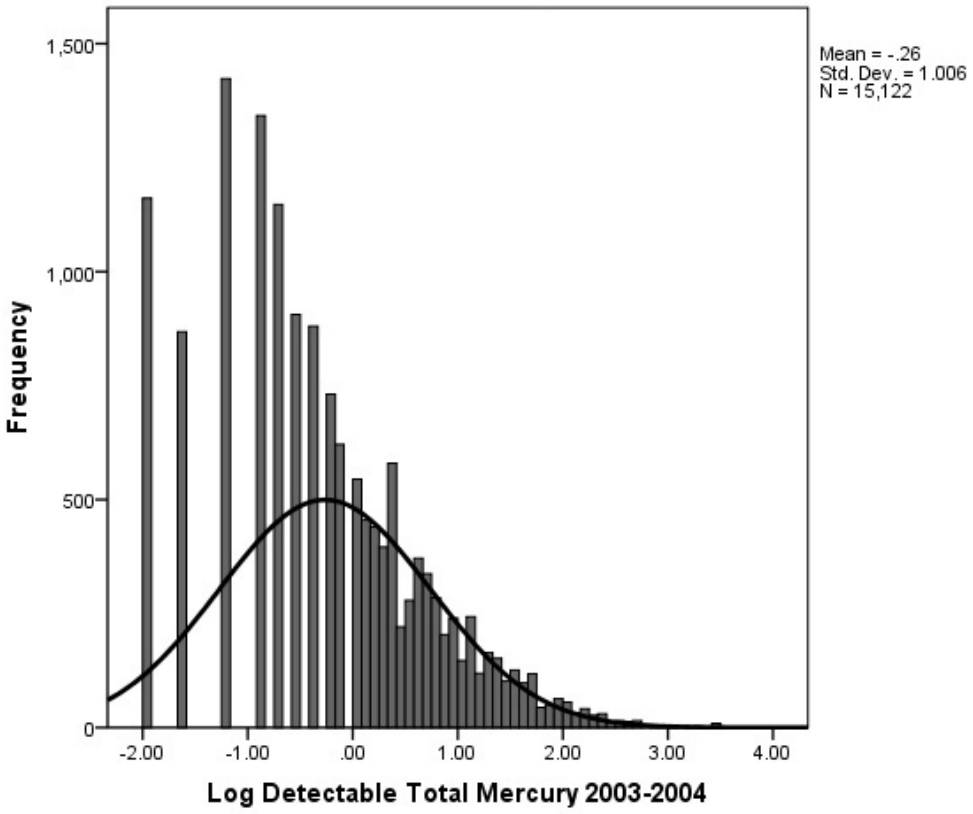


FIGURE 9

HISTOGRAM OF LOG DETECTABLE INORGANIC MERCURY (1999-2000)

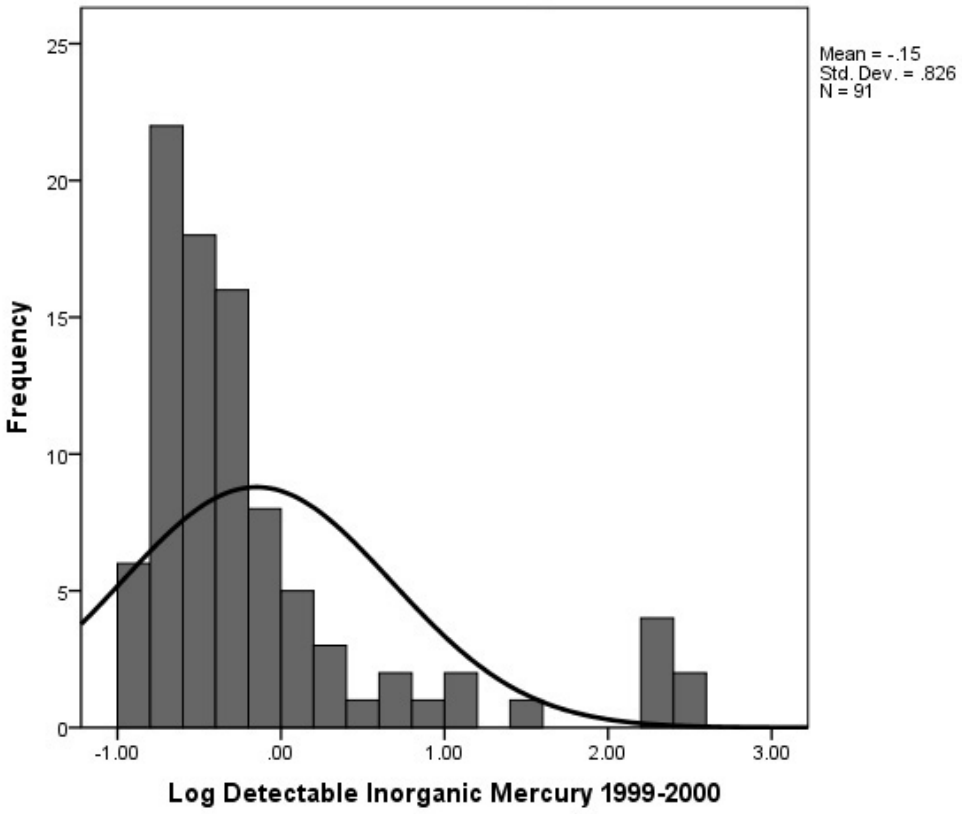


FIGURE 10

HISTOGRAM OF LOG DETECTABLE INORGANIC MERCURY (2001-2002)

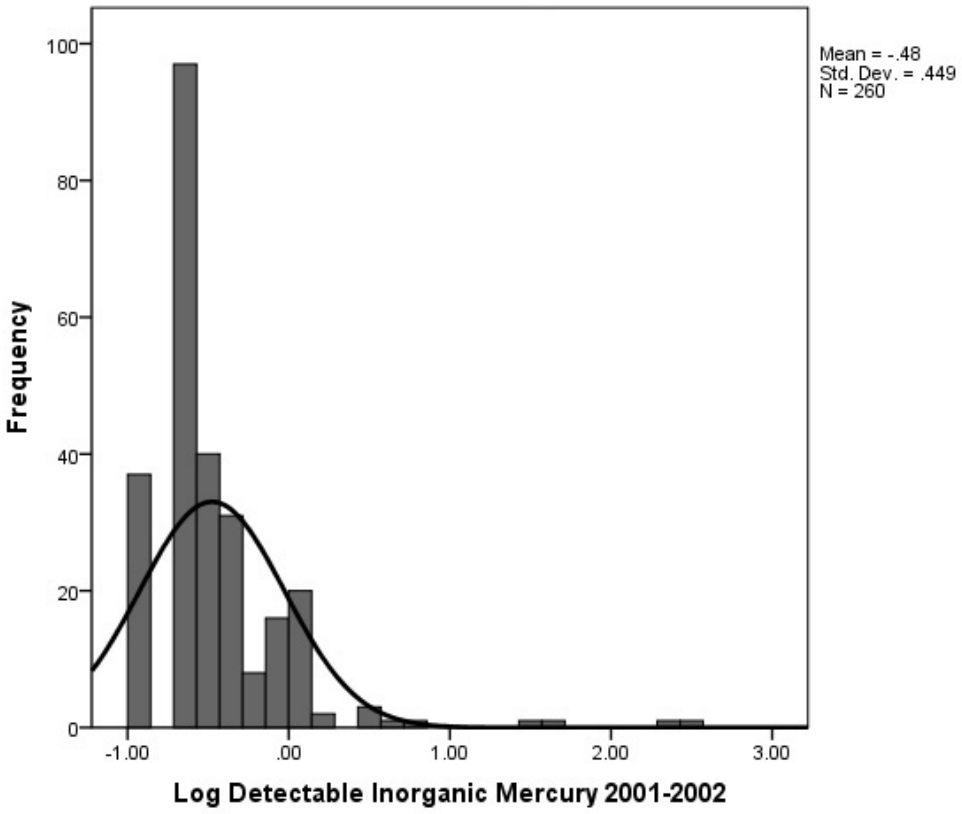


FIGURE 11

HISTOGRAM OF LOG DETECTABLE INORGANIC MERCURY (2003-2004)

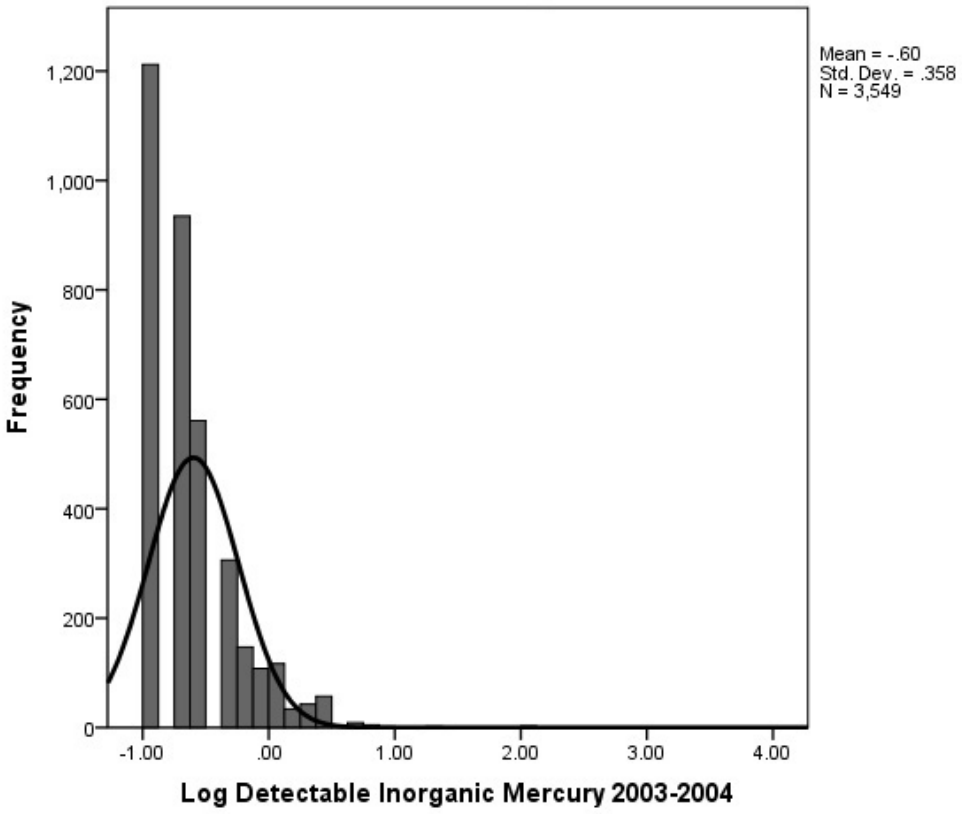


FIGURE 12

HISTOGRAM OF LOG DETECTABLE LIPID-ADJUSTED PCB 118

(1999-2000)

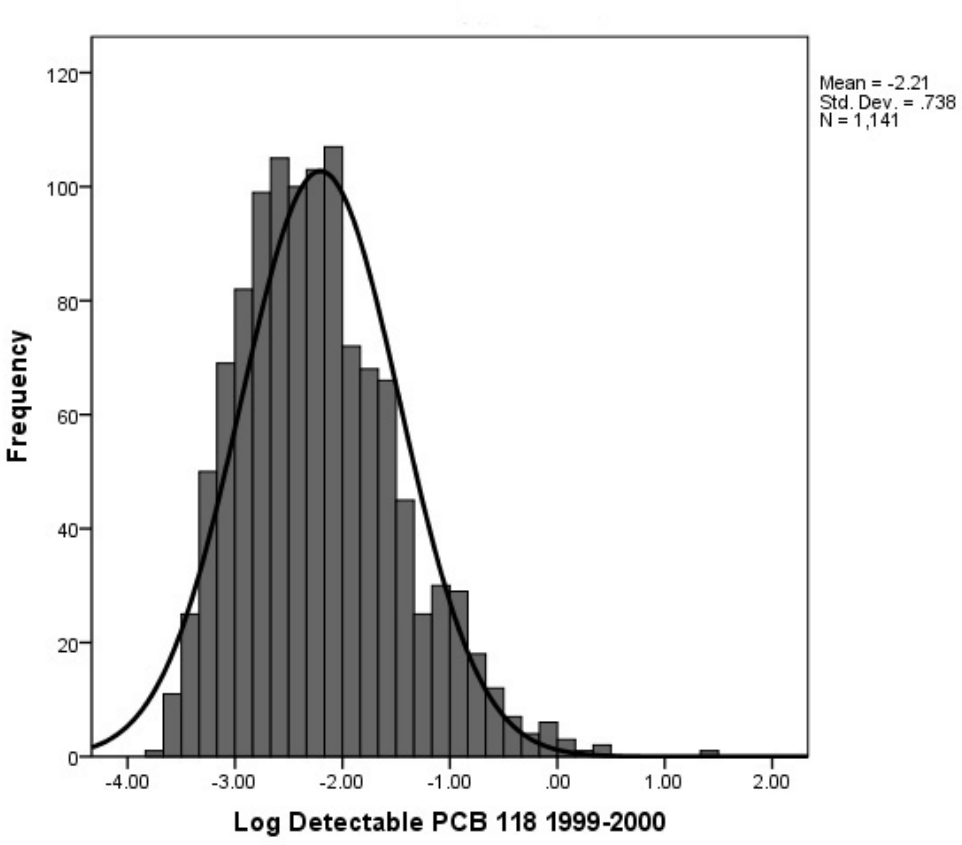


FIGURE 13

HISTOGRAM OF LOG DETECTABLE LIPID-ADJUSTED PCB 118

(2001-2002)

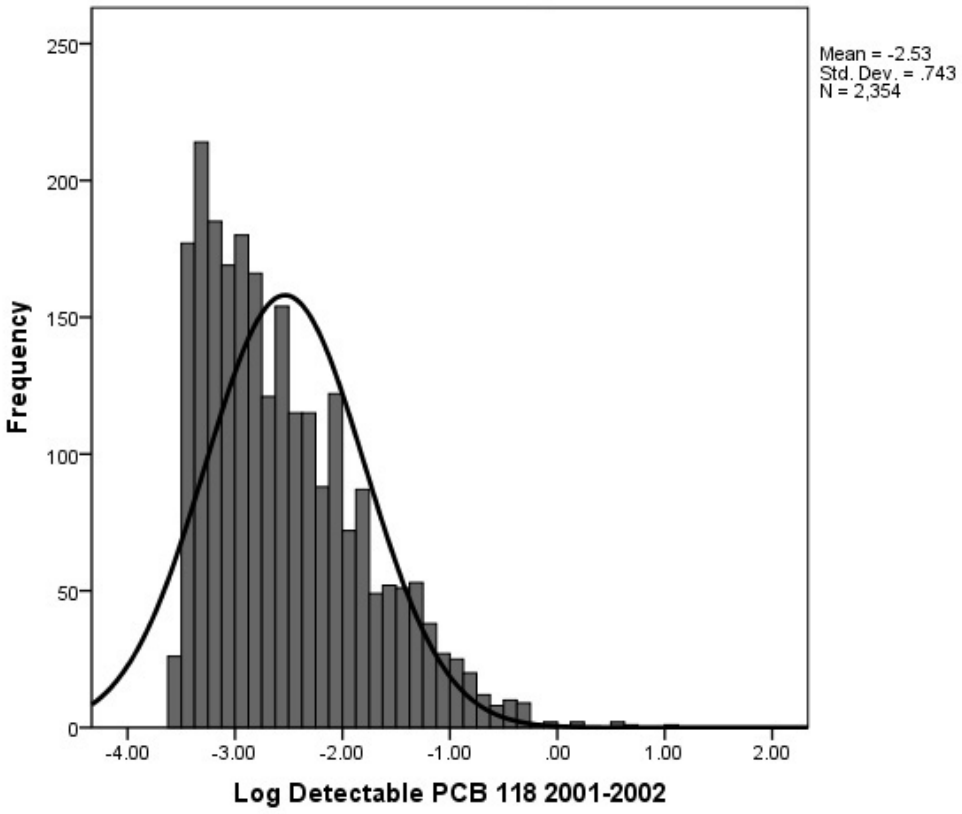


FIGURE 14

HISTOGRAM OF LOG DETECTABLE LIPID-ADJUSTED PCB 118

(2003-2004)

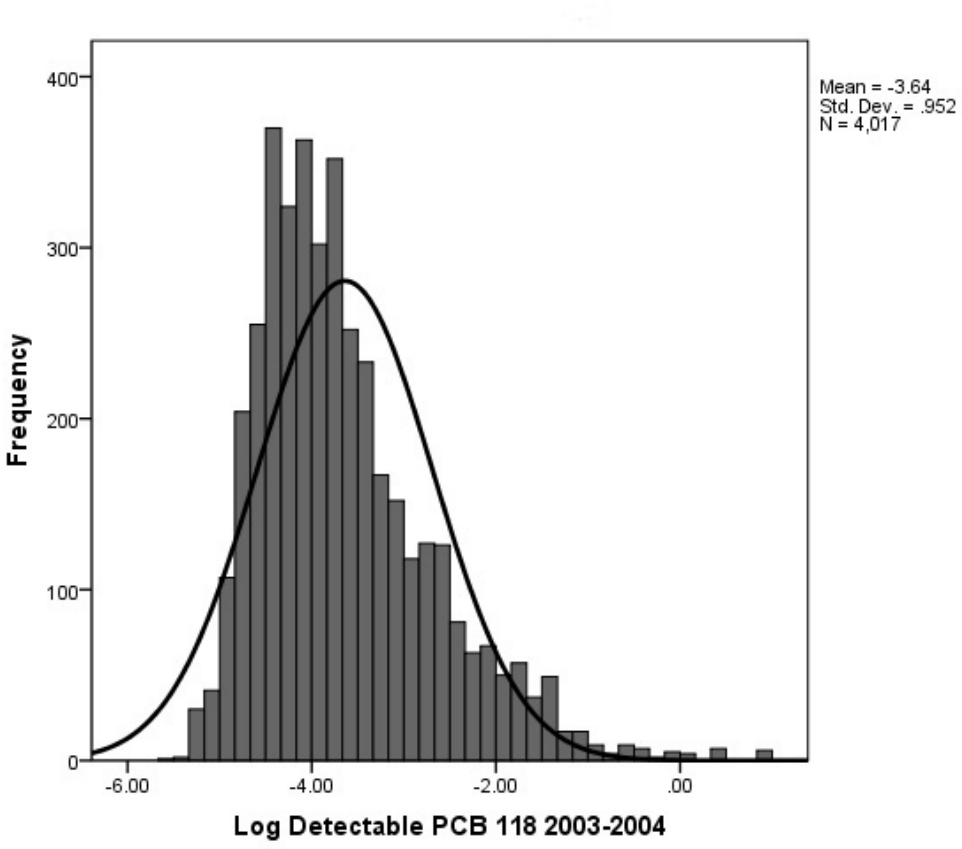


FIGURE 15

HISTOGRAM OF LOG DETECTABLE LIPID-ADJUSTED PCB 138

(1999-2000)

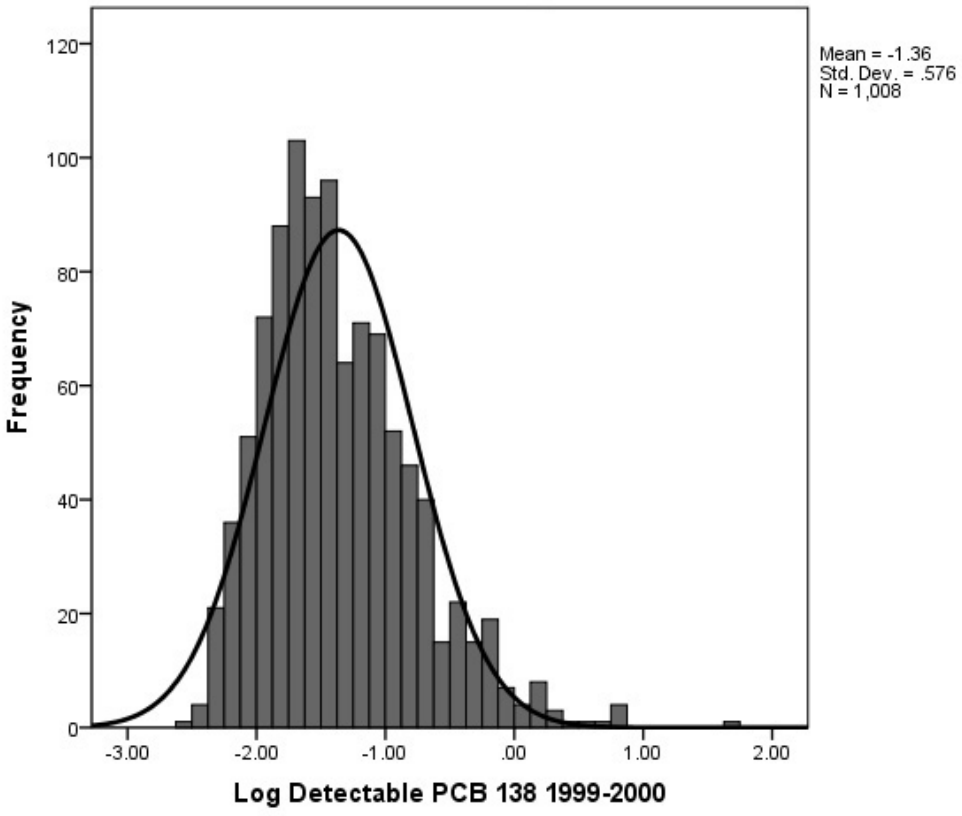


FIGURE 16

HISTOGRAM OF LOG DETECTABLE LIPID-ADJUSTED PCB 138

(2001-2002)

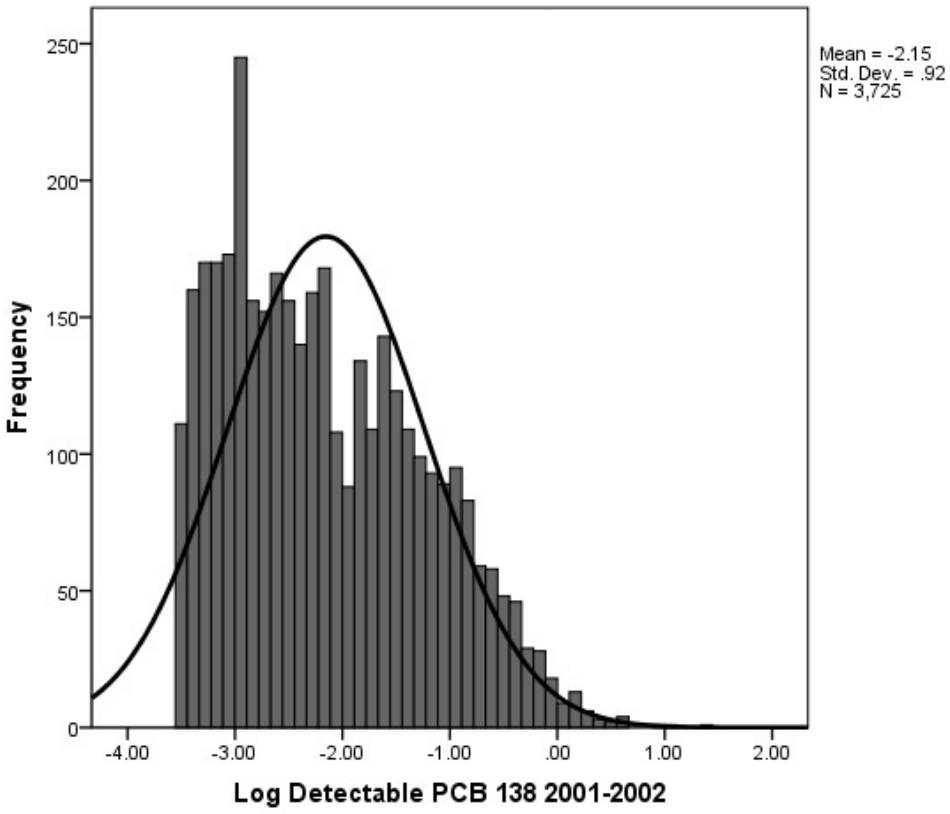


FIGURE 17

HISTOGRAM OF LOG DETECTABLE LIPID-ADJUSTED PCB 138

(2003-2004)

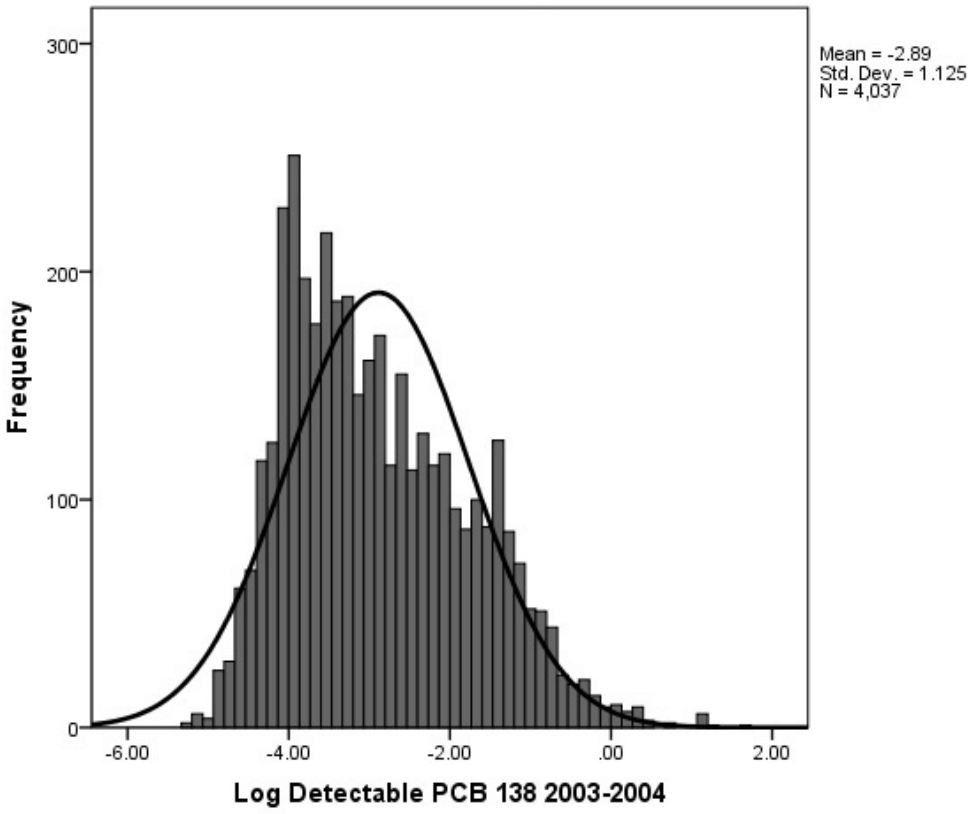


FIGURE 18

HISTOGRAM OF LOG DETECTABLE LIPID-ADJUSTED PCB 153

(1999-2000)

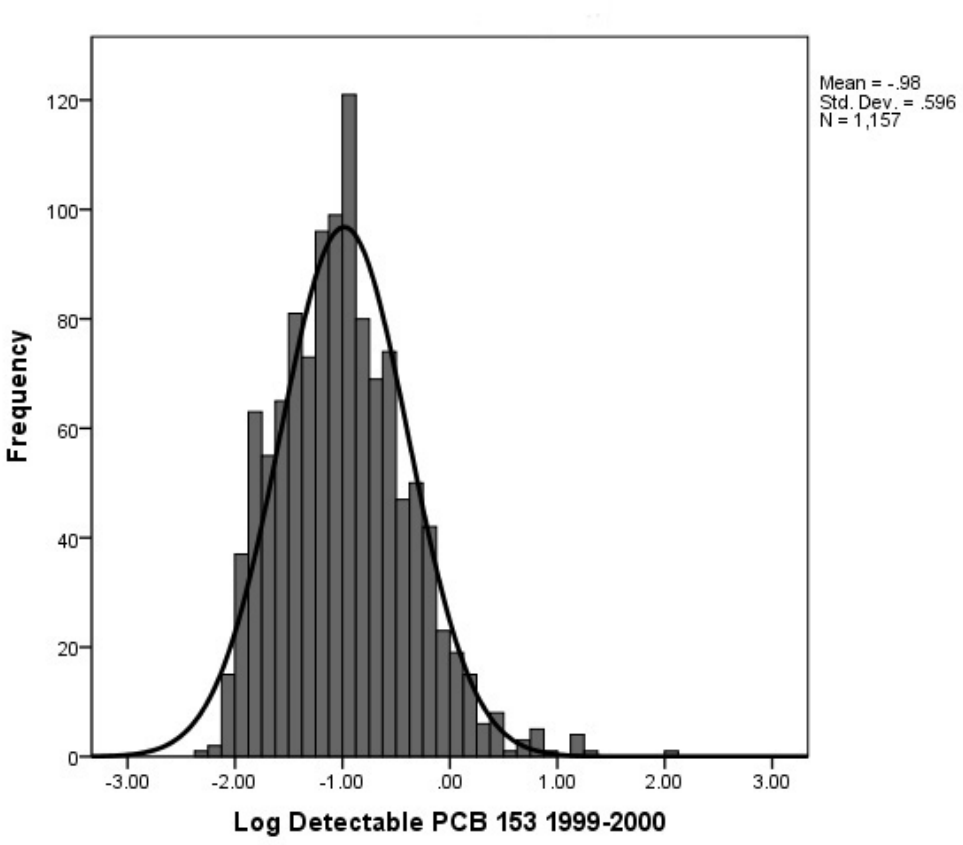


FIGURE 19

HISTOGRAM OF LOG DETECTABLE LIPID-ADJUSTED PCB 153

(2001-2002)

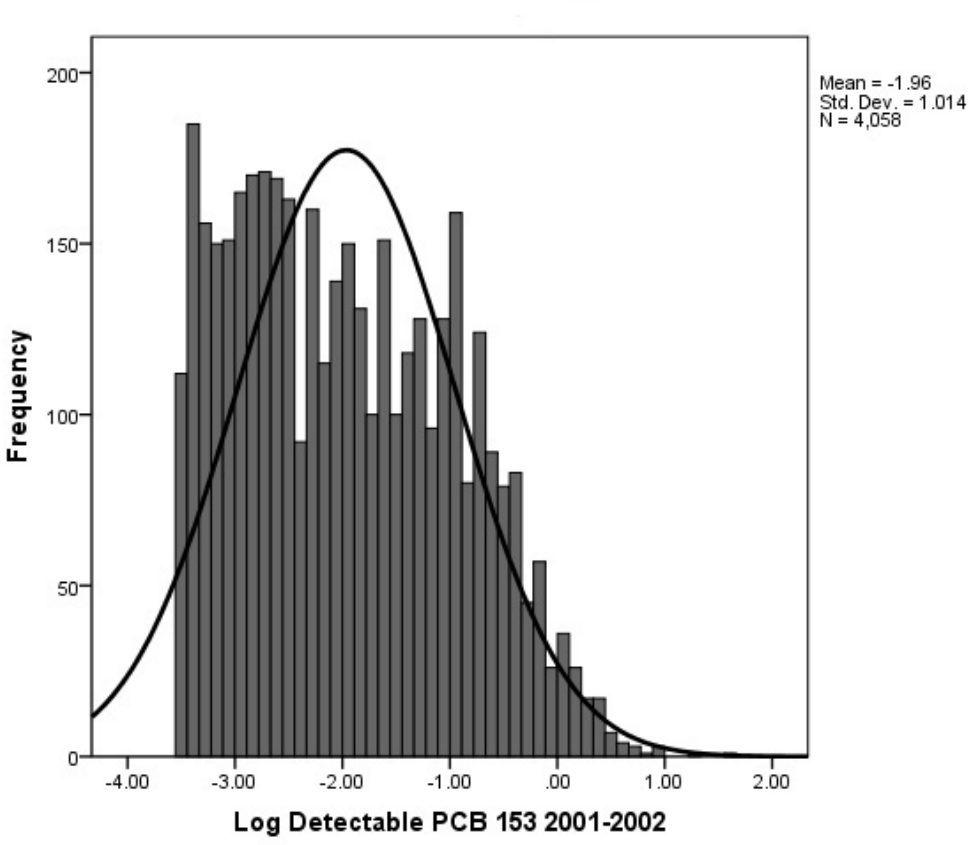


FIGURE 20

HISTOGRAM OF LOG DETECTABLE LIPID-ADJUSTED PCB 153

(2003-2004)

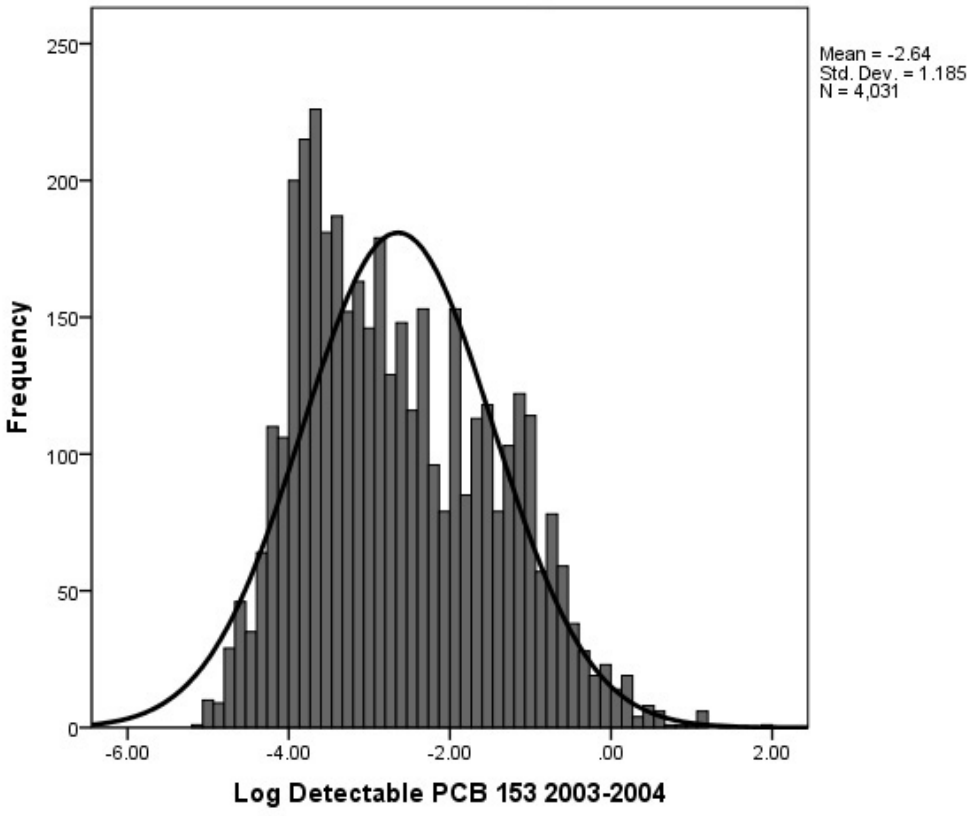


FIGURE 21

HISTOGRAM OF LOG DETECTABLE LIPID-ADJUSTED PCB 180

(1999-2000)

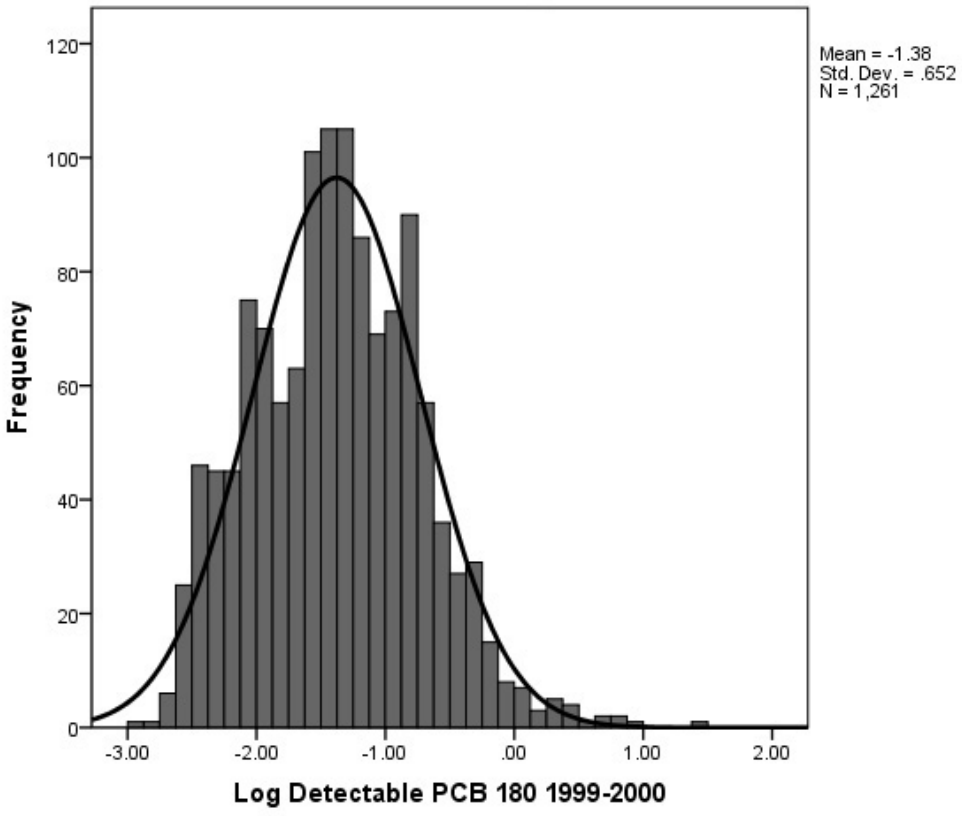


FIGURE 22

HISTOGRAM OF LOG DETECTABLE LIPID-ADJUSTED PCB 180

(2001-2002)

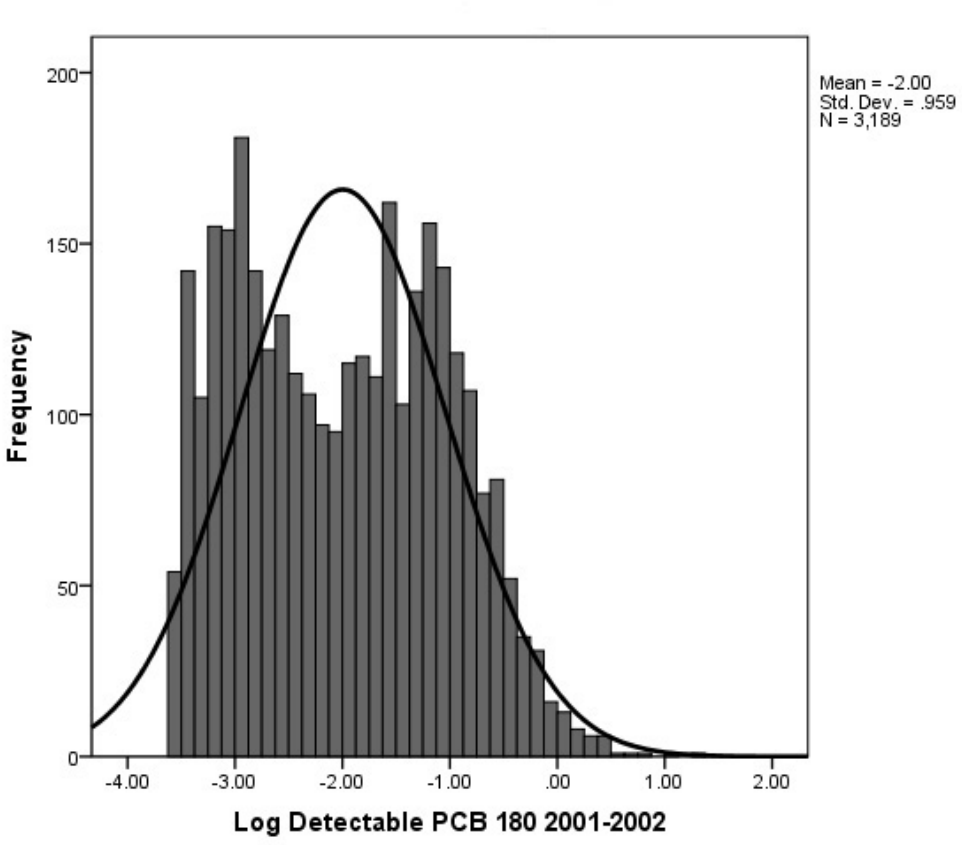


FIGURE 23

HISTOGRAM OF LOG DETECTABLE LIPID-ADJUSTED PCB 180

(2003-2004)

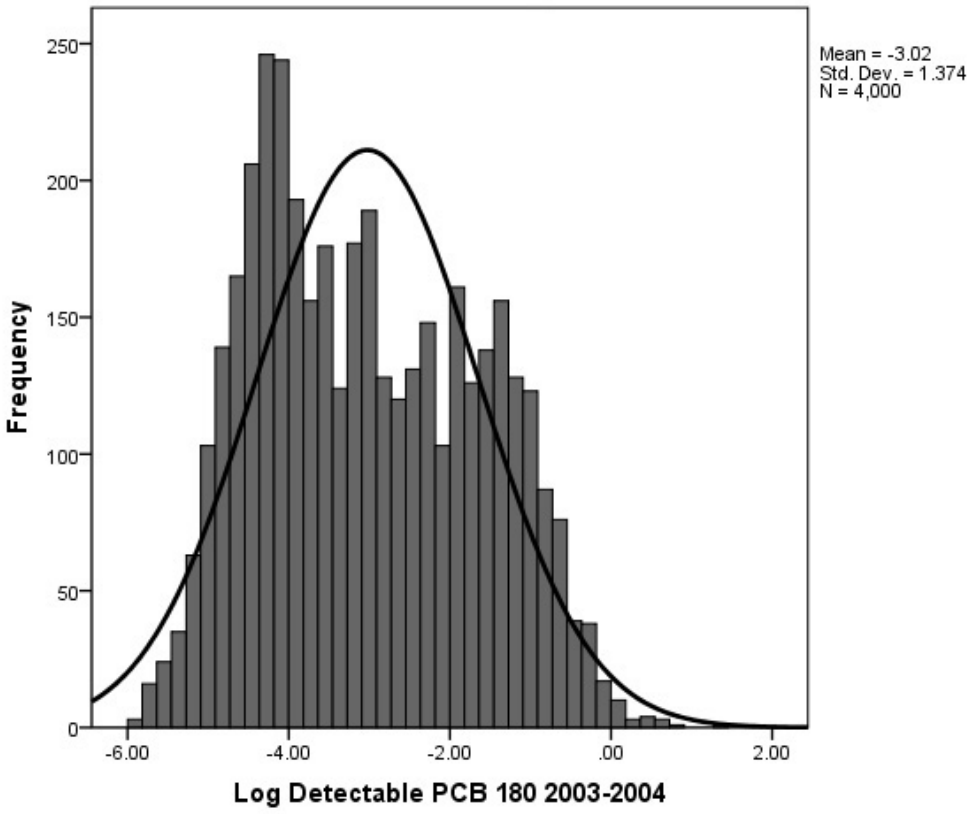


FIGURE 24

FREQUENCY DISTRIBUTION OF LEAD

PRIOR TO LOGARITHMIC TRANSFORMATION (1999-2004)

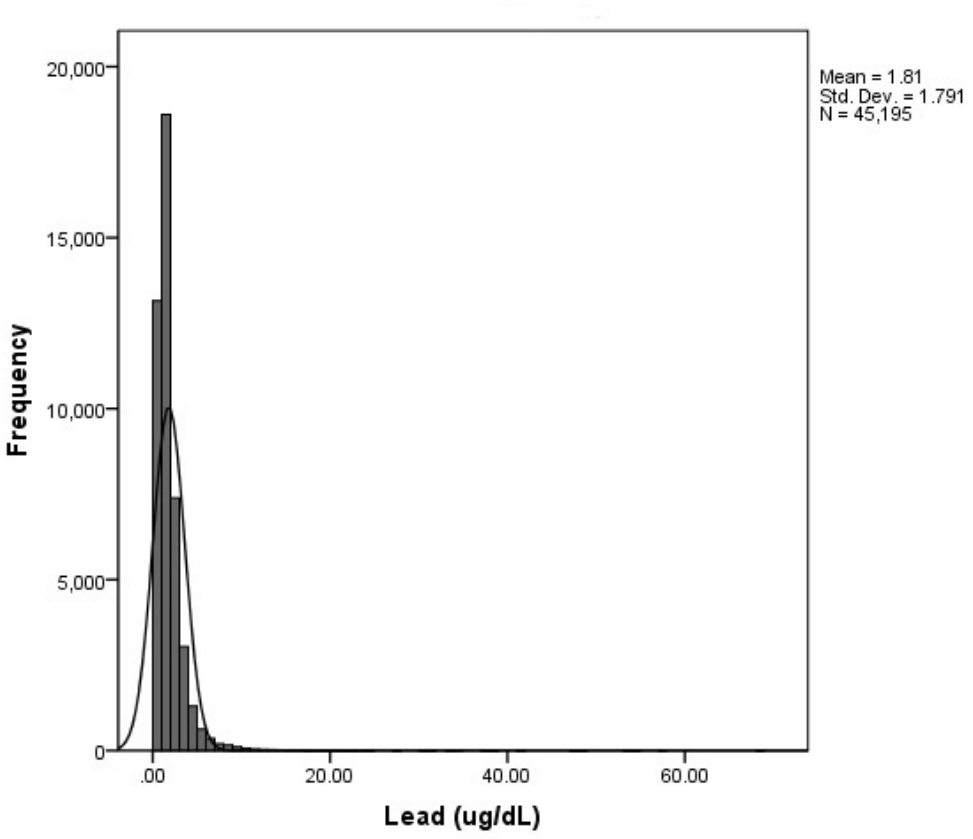


FIGURE 25

FREQUENCY DISTRIBUTION OF METHYLMERCURY

PRIOR TO LOGARITHMIC TRANSFORMATION (1999-2004)

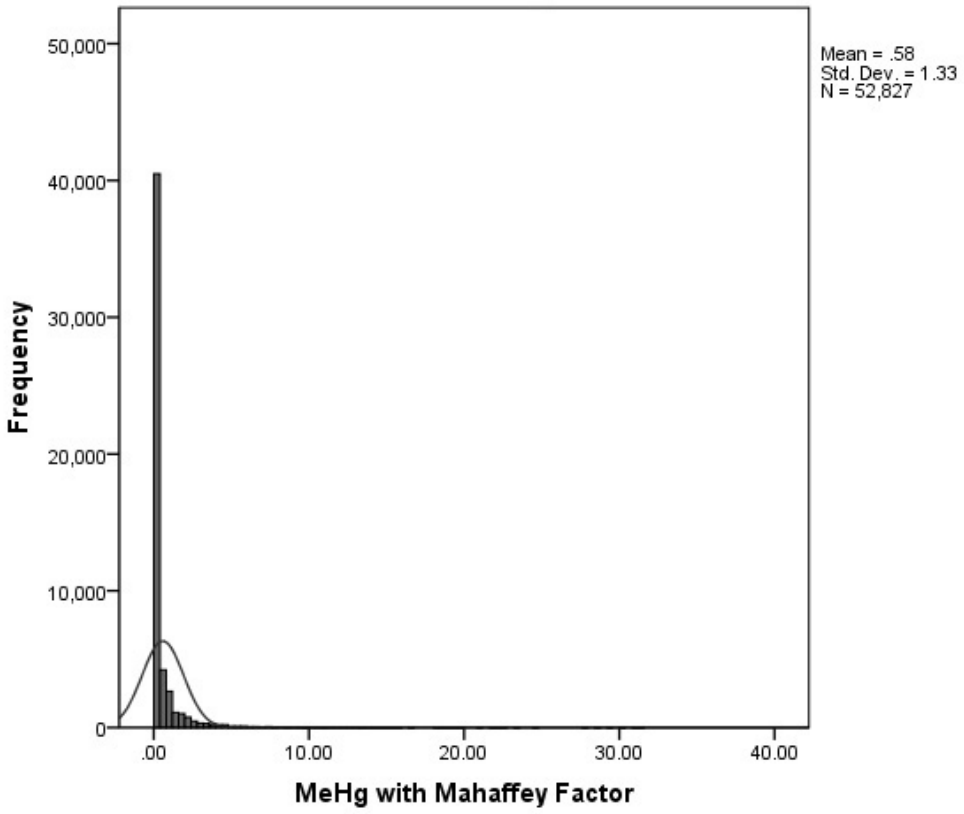


FIGURE 26

FREQUENCY DISTRIBUTION OF LIPID-ADJUSTED SUM OF PCBS

PRIOR TO LOGARITHMIC TRANSFORMATION (1999-2004)

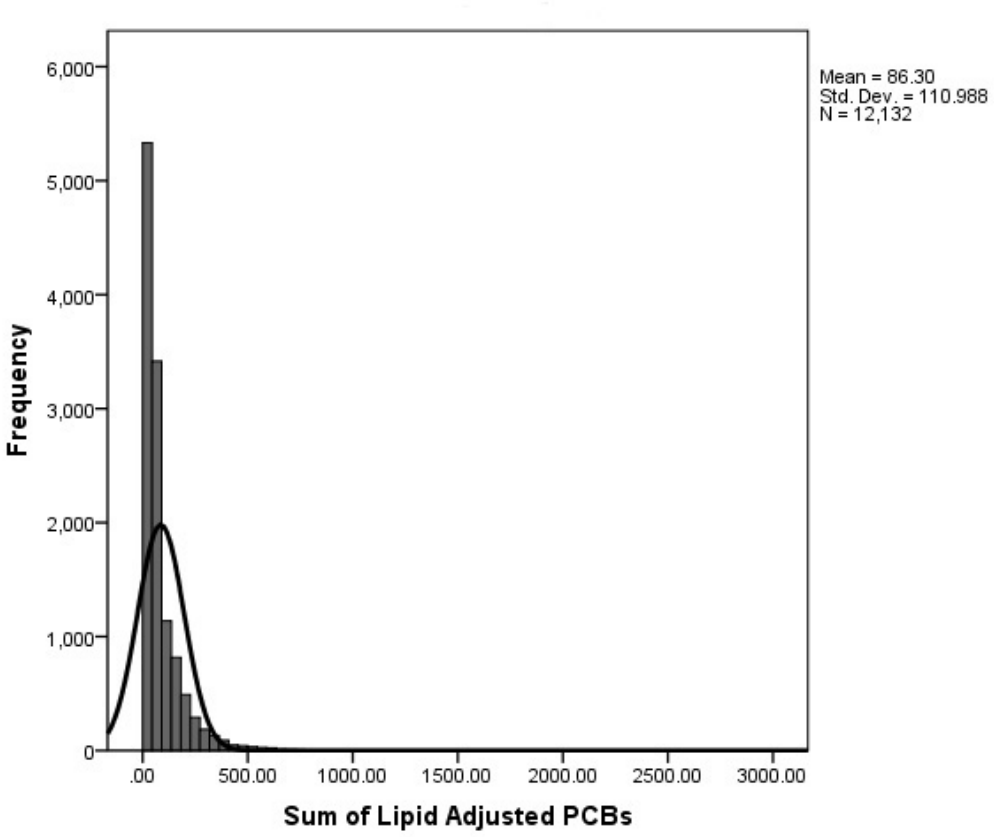


FIGURE 27

FREQUENCY DISTRIBUTION OF LEAD

POST LOGARITHMIC TRANSFORMATION (1999-2004)

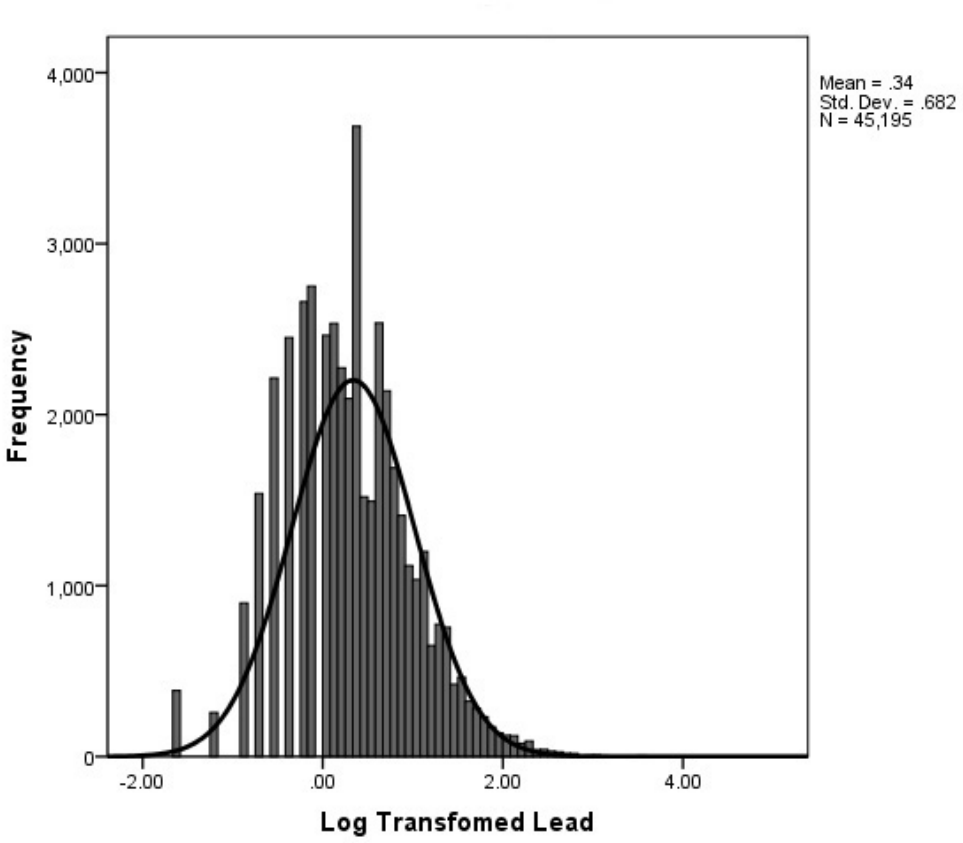


FIGURE 28

FREQUENCY DISTRIBUTION OF METHYLMERCURY

POST LOGARITHMIC TRANSFORMATION (1999-2004)

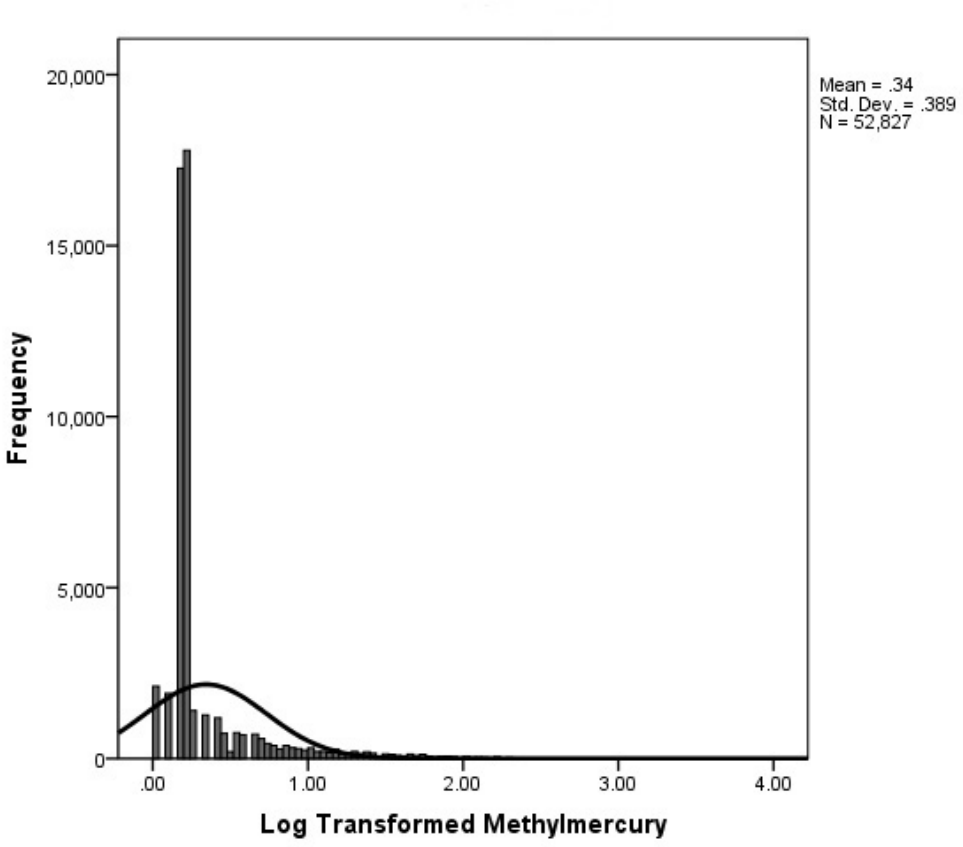


FIGURE 29

FREQUENCY DISTRIBUTION OF LIPID-ADJUSTED PCBS

POST LOGARITHMIC TRANSFORMATION (1999-2004)

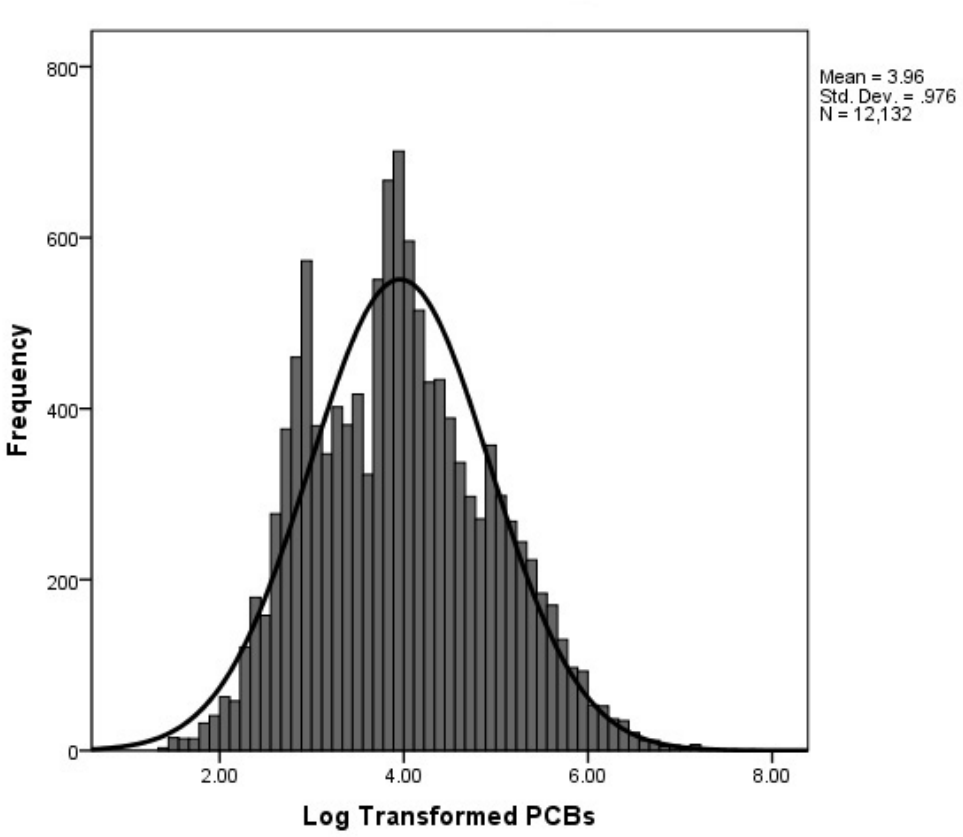


FIGURE 30

HISTOGRAM OF LOG DETECTABLE COTININE (1999-2000)

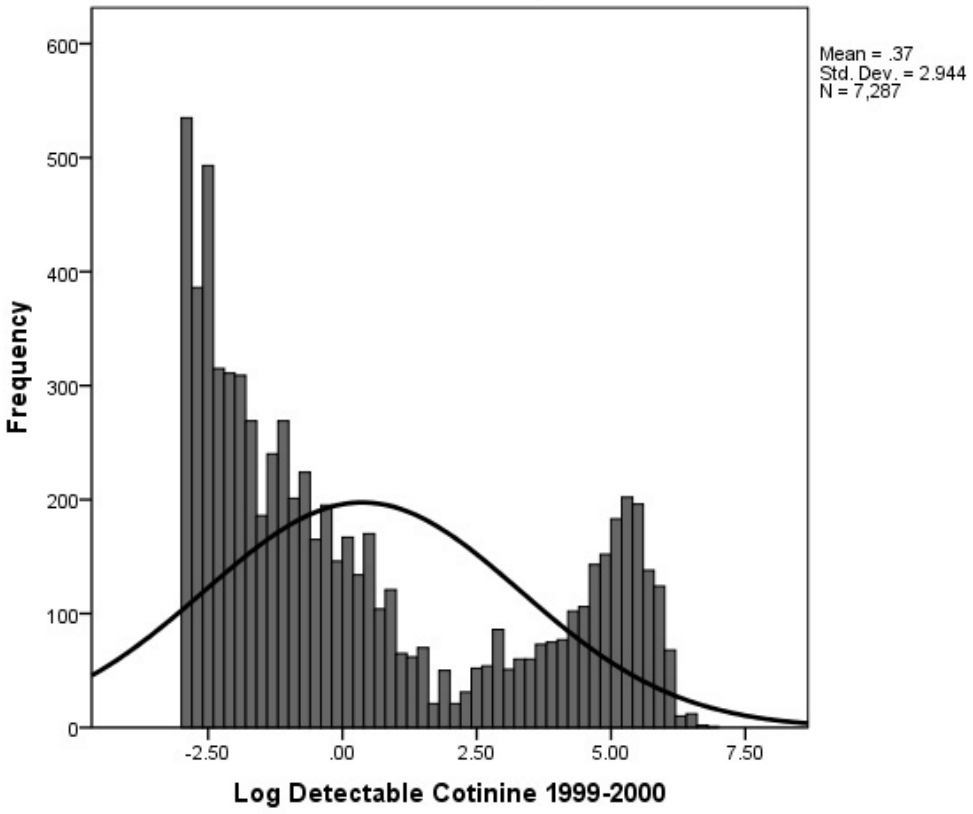


FIGURE 31

HISTOGRAM OF LOG DETECTABLE COTININE (2001-2002)

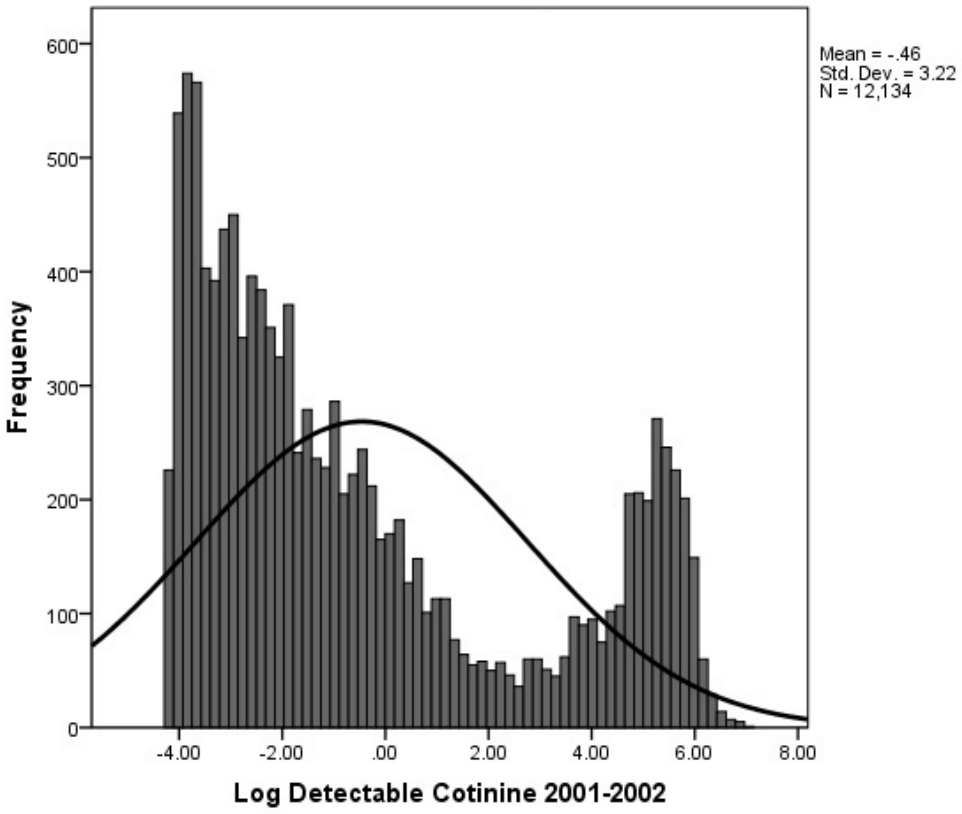


FIGURE 32

HISTOGRAM OF LOG DETECTABLE COTININE (2003-2004)

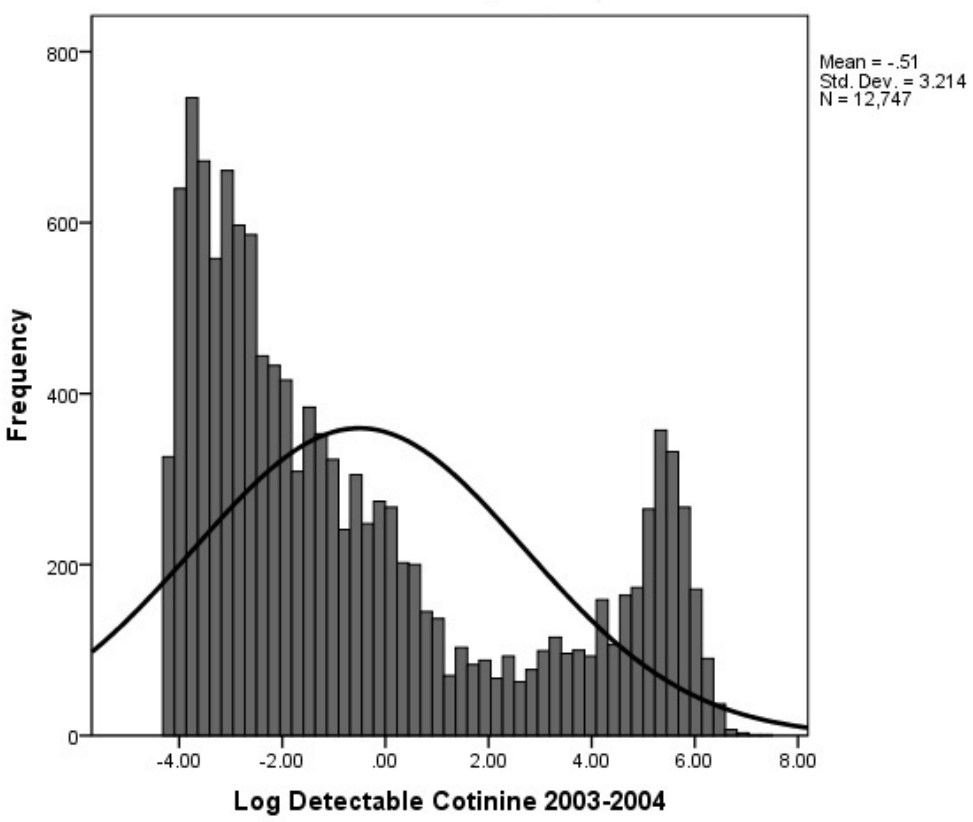


FIGURE 33

FREQUENCY DISTRIBUTION OF COTININE

PRIOR TO LOGARITHMIC TRANSFORMATION (1999-2004)

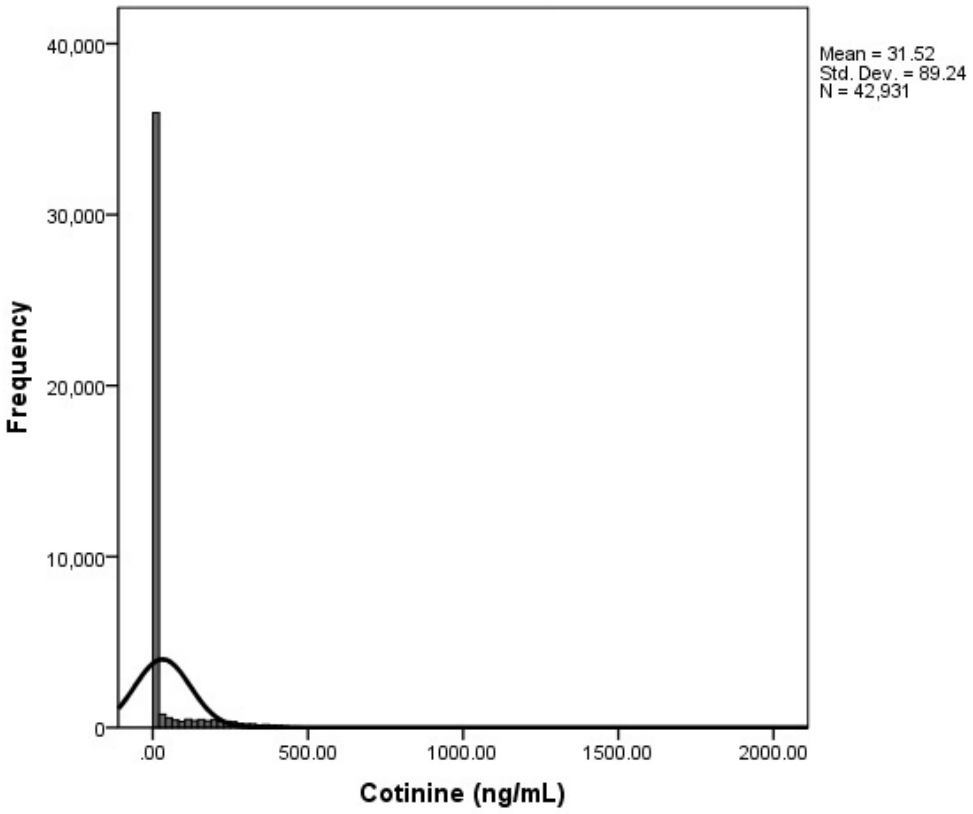


FIGURE 34

FREQUENCY DISTRIBUTION OF COTININE

POST LOGARITHMIC TRANSFORMATION (1999-2004)

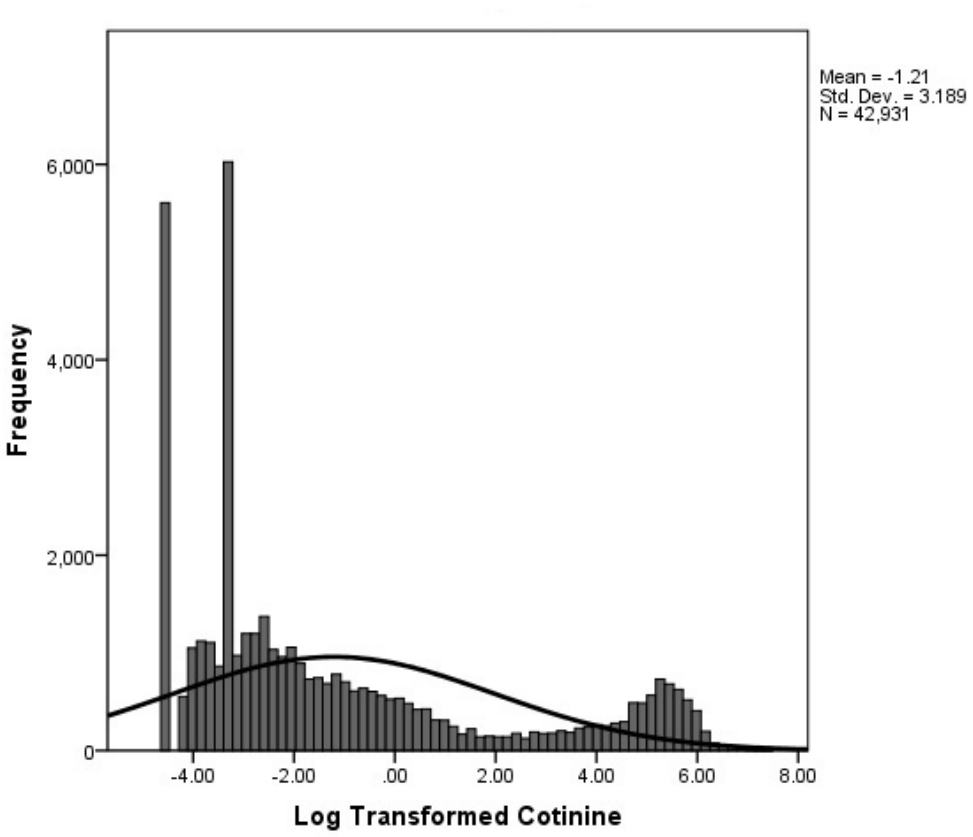


Figure 37. Exposure as Outcome with Four Categories: Percentage of Childbearing-Aged Females in U.S. with Xenobiotic Blood Levels At or Above the Geometric Mean (weighted data 1999-2004)

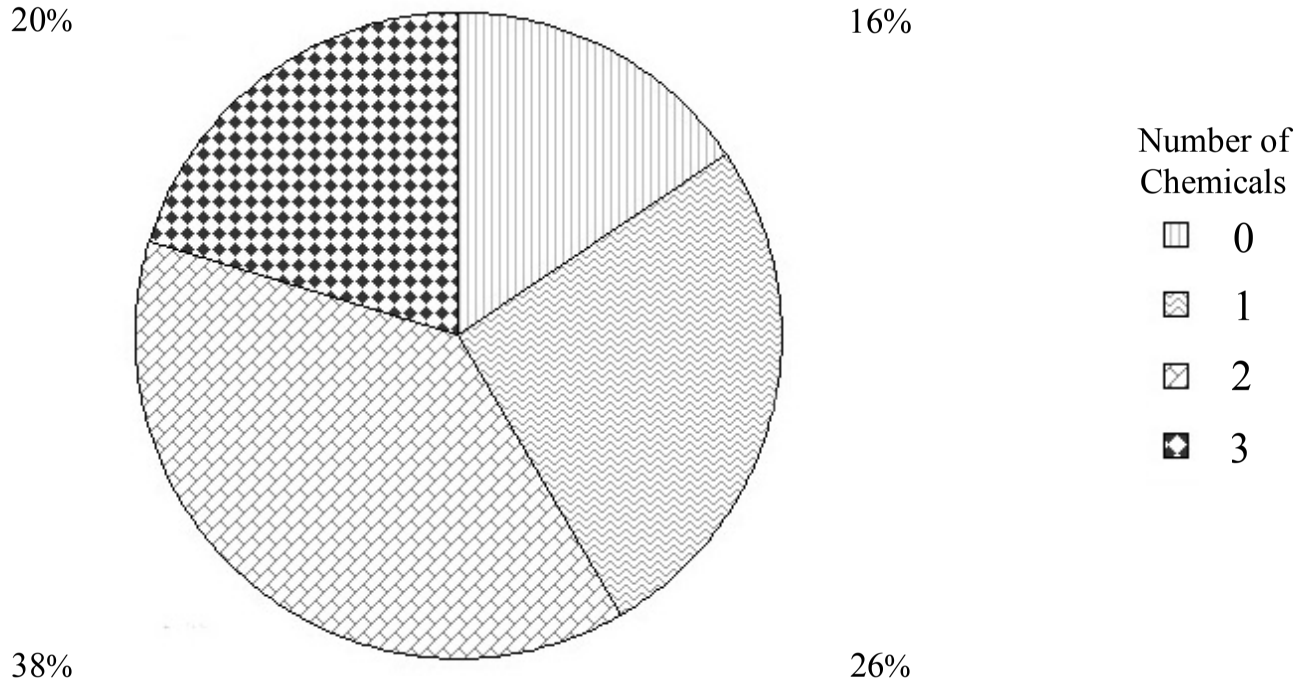


Figure 38. Exposure as Outcome with Four Categories: Percentage of Pregnant Childbearing-Aged Females in U.S. with Xenobiotic Blood Levels At or Above the Geometric Mean (weighted data 1999-2004)

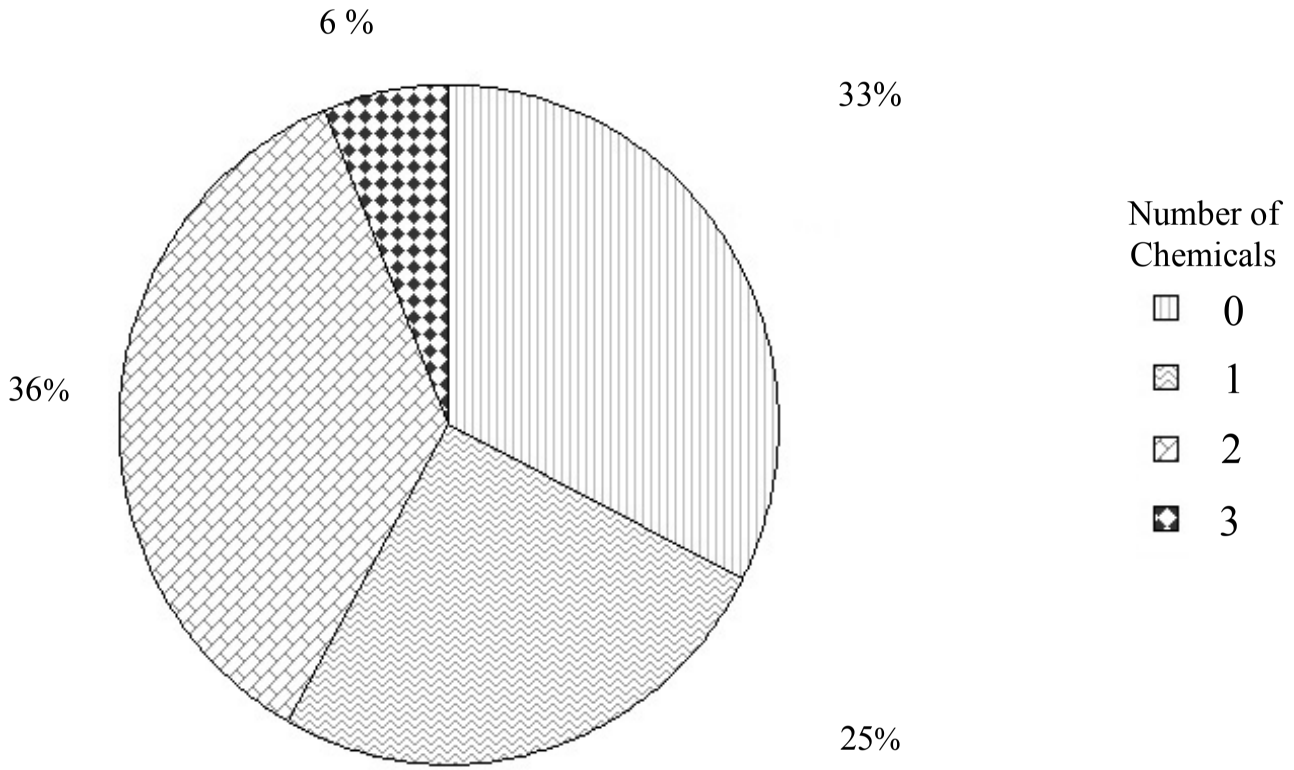


Figure 39. Exposure as Outcome with Two Categories: Percentage of Childbearing-Aged Females in U.S. with Xenobiotic Blood Levels At or Above the Geometric Mean (weighted data 1999-2004)

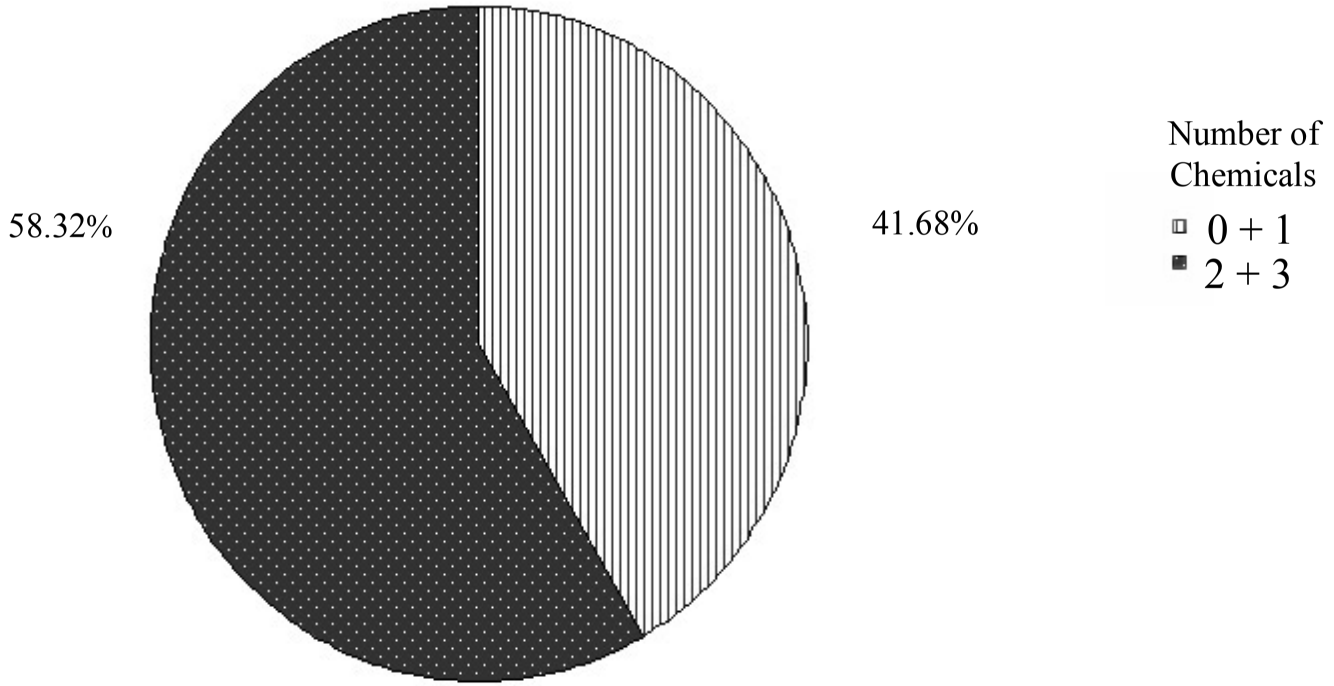


Figure 40. Exposure as Outcome with Two Categories: Percentage of Pregnant Childbearing-Aged Females in U.S. with Xenobiotic Blood Levels At or Above the Geometric Mean (weighted data 1999-2004)

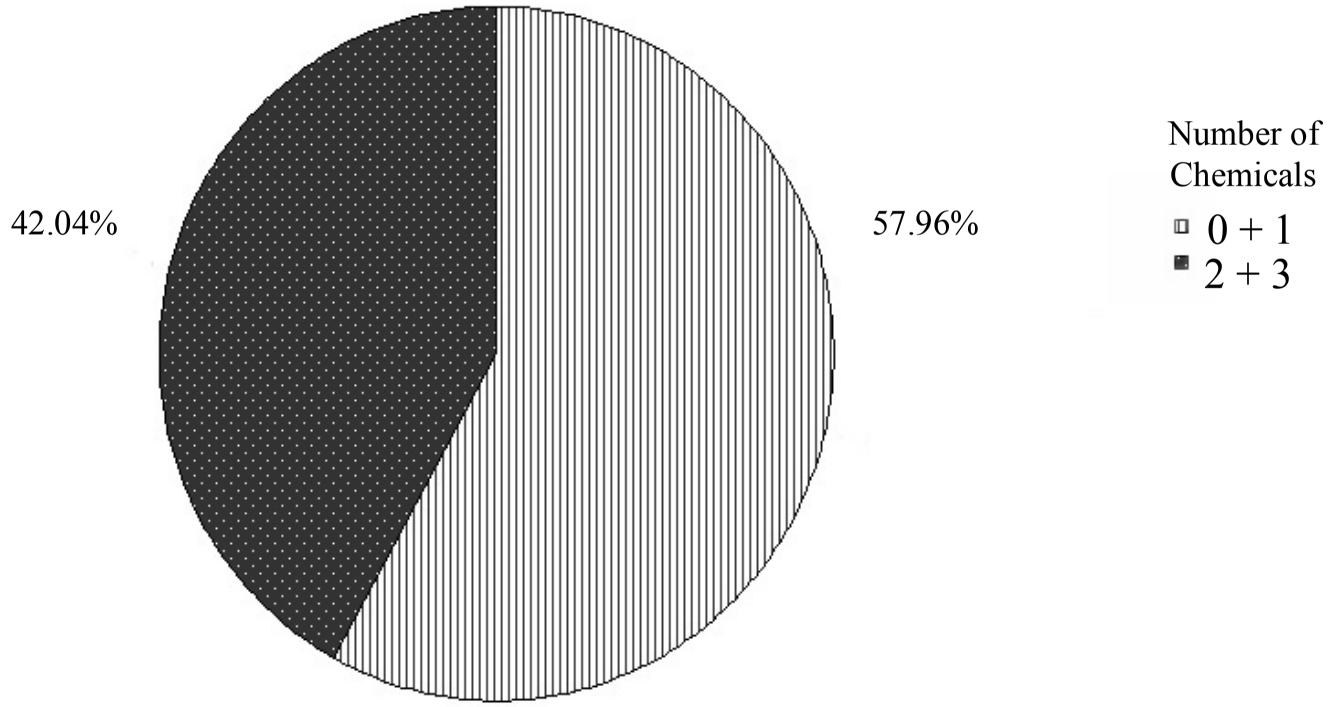


Figure 41. Odds of Childbearing-Aged Females in U.S. Having Two or More Xenobiotic Blood Levels At or Above the Geometric Mean Based on Fish Meals Eaten Past 30 Days (1999-2004)

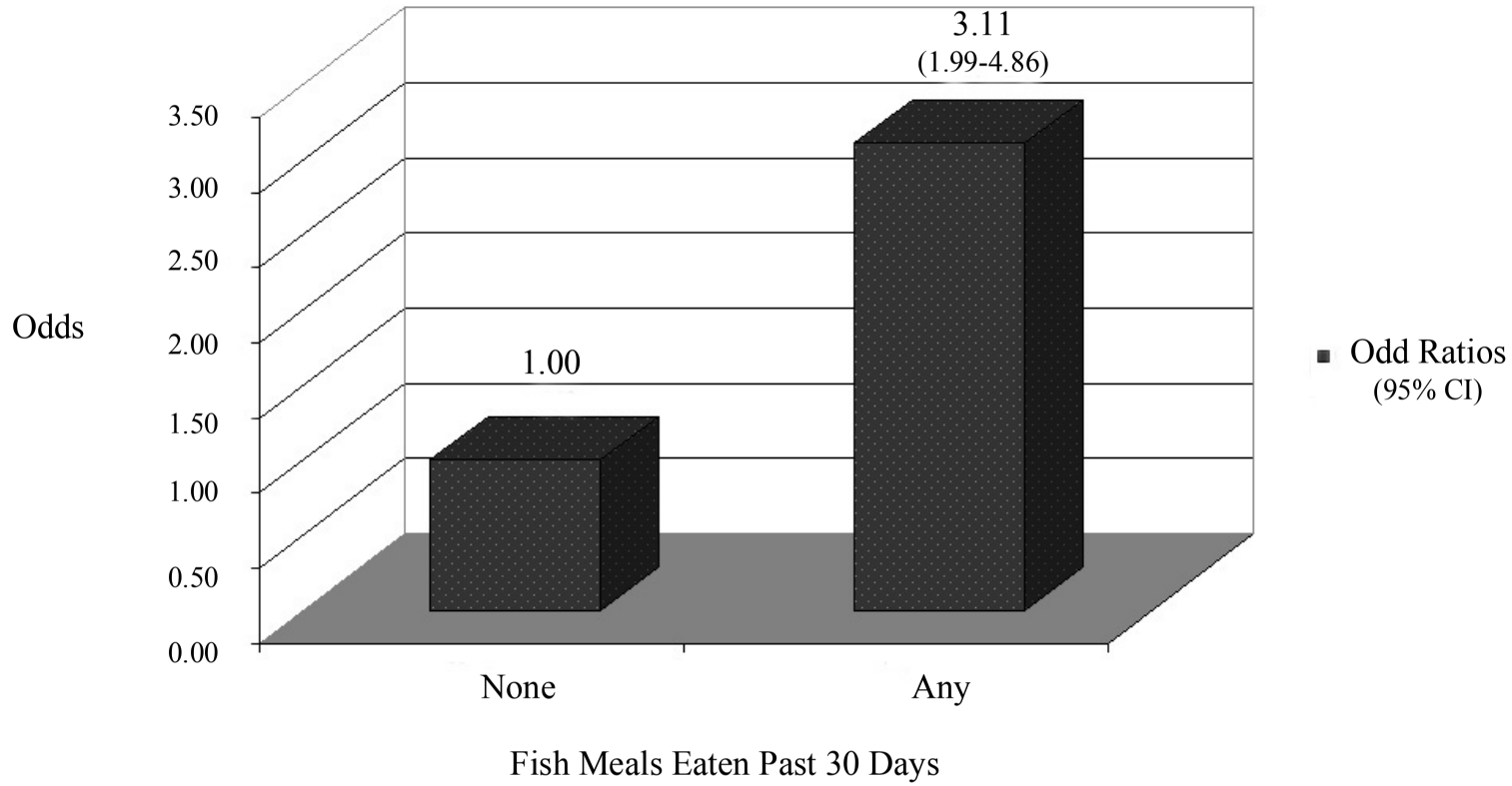


Figure 42. Odds of Childbearing-Aged Females in U.S. Having Two or More Xenobiotic Blood Levels At or Above the Geometric Mean Based on Age (1999-2004)

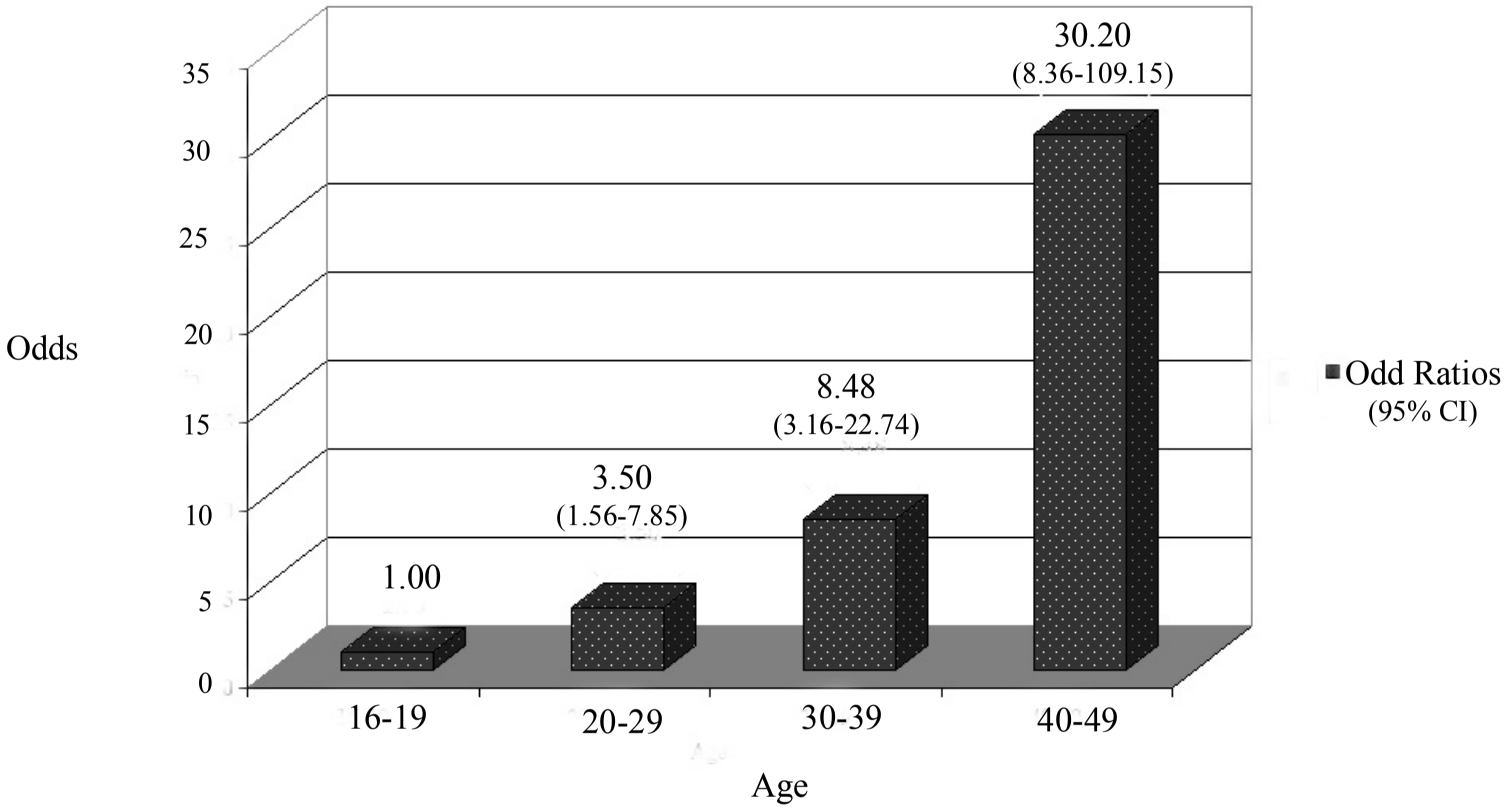


Figure 43. Odds of Childbearing-Aged Females in U.S. Having Two or More Xenobiotic Blood Levels At or Above the Geometric Mean Based on Breastfeeding (1999-2004)

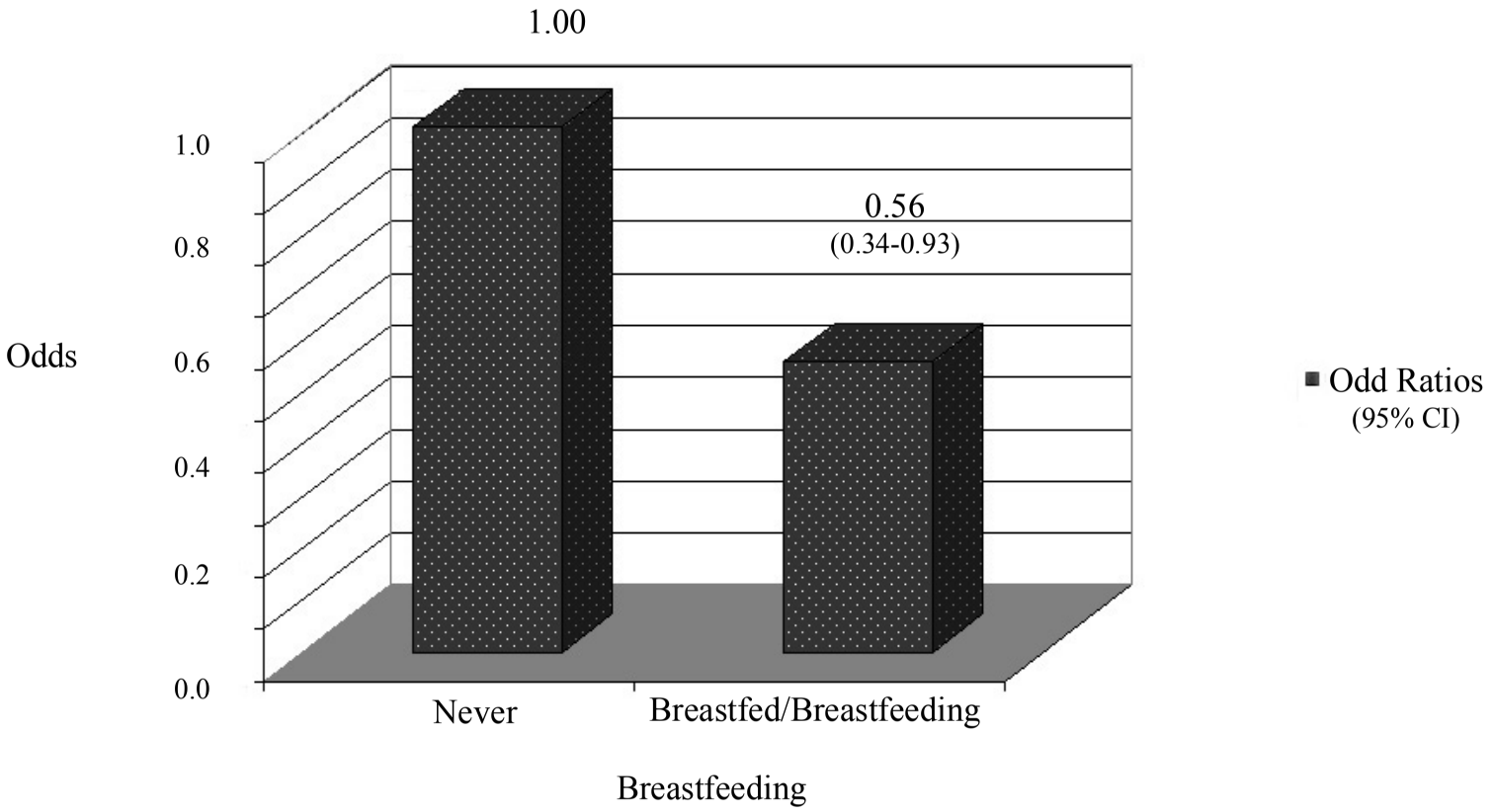
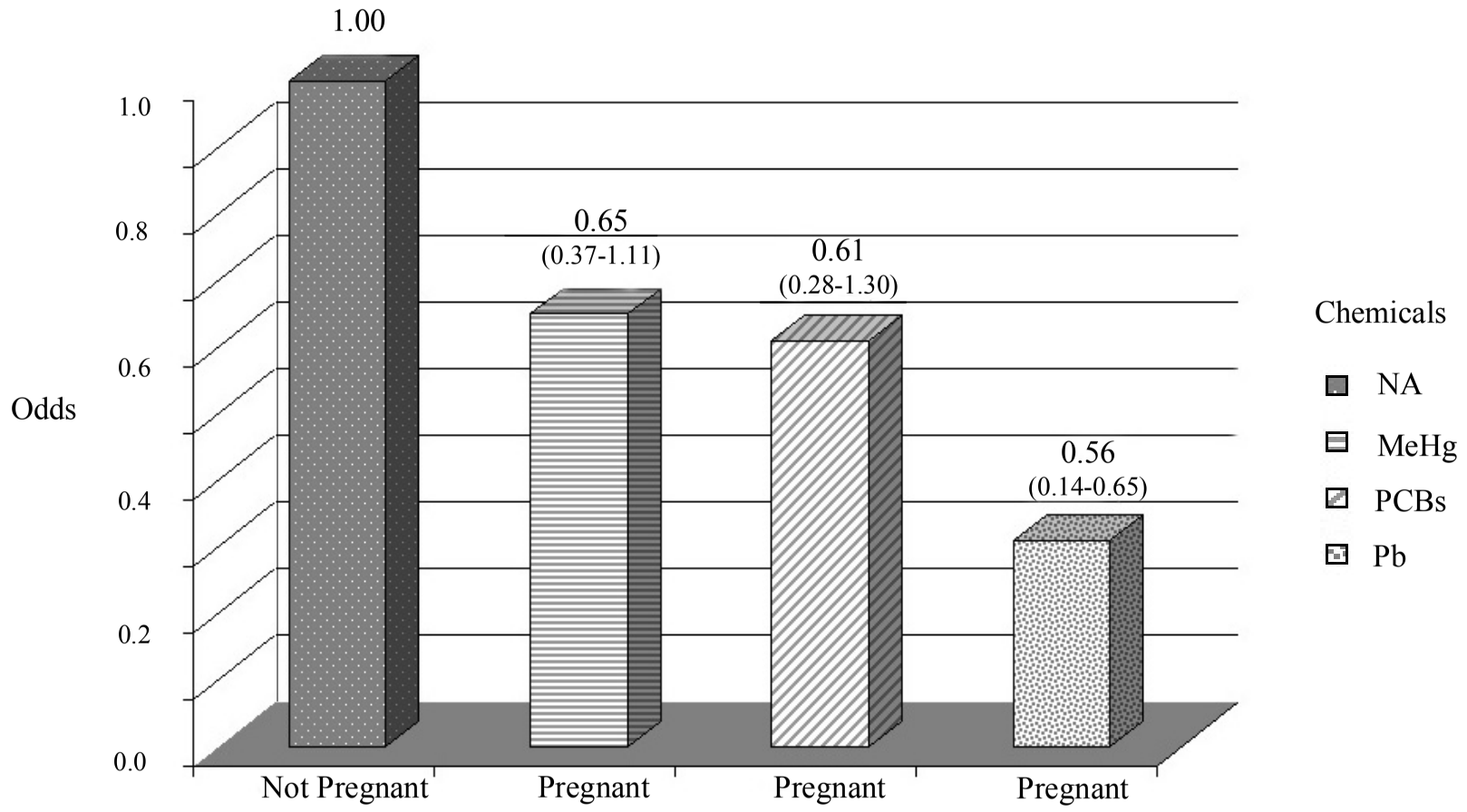


Figure 44. Odds of Childbearing-Aged Females in U.S. Having Two or More Xenobiotic Blood Levels At or Above the Geometric Mean by Pregnancy Status (1999-2004)



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